FUNDAMENTALS OF FARMING AND FARM LIFE

KYLE AND ELLIS

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Fig. 1a. Tilling the soil—the old way. "The Spaders," by Millet.

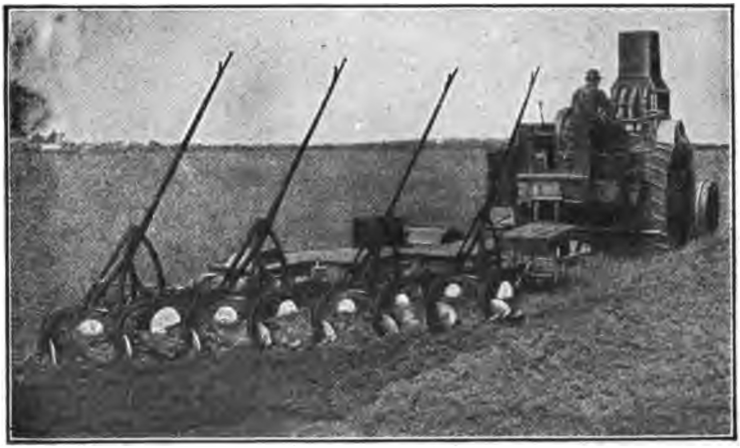

Fig. 1b. Tilling the soil—the new way. The oil pull plough.

By courtesy of the M. Rumely Company

FUNDAMENTALS OF FARMING AND FARM LIFE

BY

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ILLUSTRATED

CHARLES SCRIBNER'S SONS
NEW YORK CHICAGO BOSTON

PREFACE

While there have been great strides in recent years in the development of text-books on elementary agriculture, the best texts are still unsatisfactory in many ways. The defects complained of arise largely out of the fact that these texts are usually prepared by busy scientists who, though they may know agriculture, have made little study of the mental processes of children, have had little or no experience in teaching children, and are not very familiar with the exact conditions in the schools in which the texts are to be used. The result is that the subject-matter has not always been wisely chosen in the light of children's natural interests and needs, nor has the subject-matter that was chosen been organized in a careful, pedagogical manner, by starting always with the known, leading to the unknown through the known, and making the study a closely knit, coherent, living whole. Indeed, several of the texts are mere collections of articles on a dozen or more varied topics written by specialists in different institutions and without any common plan of organization or method of presentation. The children are not introduced gradually to the new technical terms, nor are proper apperceptive bases first laid before attempting to present the more complex processes of plant or animal growth.

It was thought that by combining the efforts of the agricultural professor with those of the pedagogue it would be

possible to provide a text-book on elementary agriculture that would have the advantage of the accuracy and scholarship of the specialist in agriculture, and have also the organization and pedagogical manner of presentation given to it by the specialist in education familiar with the conditions in the rural schools. All of the chapters were therefore first prepared on a uniform general plan by experts in the several fields and turned in to the pedagogical editor, who attempted to put each chapter into more teachable form and to organize the whole. It is believed that because of the carefully graded steps in the subject-matter, the preparation that is always provided for each new subject, and the simple language used the pupil can in this text cover with little difficulty much more ground and learn more complicated processes than he can with the usual text.

It was also the purpose of the authors to provide a book that did not stop with giving mere advice about farm practices to be memorized by the pupils, but taught first of all the fundamental principles of plant and animal growth and reproduction and of soil management. In this way the pupils are made able to understand the reasons for farm practices and to criticise any old or new practice independently. By emphasizing these far-reaching principles first, the thousand and one details of practice in the study of farm crops and animal husbandry which are later given become a matter for simple reasoning instead of a mere dead weight to be carried in memory. In order still further to develop the powers of observation, exercise the reason, and connect the lessons with the daily life and home needs of the pupils, lists of suggestive questions, exercises, and problems are provided for each subject.

It is an astonishing fact that no text-book has given to the work of the farmer girls and farmers' wives more than a passing mention. Undoubtedly, the conditions in the country schools make this problem difficult, but it is believed that, with the aid of the experts in domestic economy and rural teaching who generously co-operated, a very valuable beginning has been made in this text in enabling the school to give somewhat the same preparation for her life work on the farm to the farmer girl that is now given to the farmer boy.

We have in general tried to broaden the conception of the course in elementary agriculture from that of a mere treatise on raising plants and animals for sale to that of a means of preparation for living intelligently and happily, as well as profitably, on the farm.

It is a great pleasure to express here our appreciation of the assistance generously given by our colleagues in preparing this book.

Members of the faculty of the Agricultural and Mechanical College of Texas prepared material for chapters as follows: Professor J. C. Burns, Professor of Animal Husbandry, the chapters on animal husbandry, cattle, horses, sheep, hogs, and the care and feeding of animals; Professor J. O. Morgan, Professor of Agronomy, the chapters on farm crops and manures, fertilizers and rotation; Professor J. W. Ridgeway, Professor of Dairy Husbandry, the chapter on the care of milk and its products; Professor C. M. Evans, Superintendent of Agricultural Extension, the chapter on silos; Professor R. J. Potts, Professor of Highway Engineering, the chapter on roads; Instructor E. F. Ferrin, the chapter on poultry. In every case the limits of an elementary text necessitated cutting down and modifying the

valuable material and illustrations furnished. Assistance in securing illustrations or criticism and suggestions were also received from Professors G. S. Fraps, State Chemist; Wilmon Newell, State Entomologist; G. S. Templeton, S. A. McMillan, and Harper Dean.

From the Texas Agricultural Experiment Station Professor H. Ness gave assistance through criticism and suggestion, and Director B. Youngblood and Mr. J. M. Johnson, Expert in Farm Management of the United States Department of Agriculture, stationed in Texas, prepared the material for the chapter on farm planning and accounting.

Of the faculty of the University of Texas we are indebted for valuable criticism and suggestions on the first twenty-eight pages to Professor F. DeF. Heald; on plant growth, reproduction, and soils to Dr. I. McK. Lewis; on plant growth, farm crops, the garden, orchard, and shade-trees, and plant enemies to Instructor C. H. Winkler. The material for the chapter on the soils and climate of Texas was prepared by Professor F. W. Simonds, Professor of Geology; that for the chapters on the farm home and farm sanitation, home and school grounds, the preparation and use of foods, cooking in the one-room country school and sewing in the one-room country school was taken from the manuscripts of forthcoming Bulletins of the University prepared by Miss Mary E. Gearing, Professor of Domestic Economy; Miss Amanda Stoltzfus, Lecturer on Rural Schools, and Mrs. Mary Heard Ellis. To Mr. H. B. Beck, University landscape gardener, we are indebted for valuable suggestions on yard plants and plantings.

We are also indebted to Professor O. S. Morgan, of Co-

lumbia University, for very helpful criticisms and suggestions on many of the chapters.

While the authors would make every acknowledgment to their generous colleagues for the excellence of the material in the several chapters, we wish to accept entire responsibility for any inadequacy or inaccuracy that may have resulted from the revision and reduction of the material to its present form.

The many acknowledgments due for courtesies in the use of illustrative material are made in the body of the text. To Mr. D. T. Stephens we are indebted for the preparation of a large part of the drawings in the first four chapters, and to Miss Florence Rhine for several drawings in later chapters. We wish to express also our appreciation of the great assistance given by both the editorial and art departments of the publishers.

E. J. Kyle.
A. Caswell Ellis.

Austin, Texas, *August* 1, 1912.

PREFACE TO THE REVISED EDITION

TEN years of increasing use in the schoolroom and farm home have demonstrated the soundness of the material and the plan of organization of this text, so that for this new edition few changes were needed in the essential chapters. The lists of references have been thoroughly revised; the chapter on poultry has been rewritten to include new and valuable material.

The authors wish to acknowledge their indebtedness to Professor T. J. Conway of the A. & M. College of Texas for valuable assistance in the revision of the chapter on poultry, and to Professors J. O. Morgan, A. T. Potts, G. S. Templeton, S. W. Bilsing, and J. A. Clutter for assistance in revising the references for further study.

E. J. KYLE.
A. CASWELL ELLIS.

COLLEGE STATION, TEXAS, *September* 1, 1922.

SUGGESTIONS FOR THE TEACHER

WHILE the school should not try to force farmers' sons to become farmers, any more than it should force doctors' sons to become doctors, or merchants' sons to become merchants, it should at least stop leading the farmer's children directly away from the country and into the town. The teacher should encourage the natural interest which both country boys and girls, and town boys and girls, have in growing plants and animals; should show them how agriculture is receiving the best thought of many of the most intelligent men and women in the world; how it offers to them not merely a happy and useful life, but as great a field for the exercise of intelligence and character and the application of scientific methods as do commerce, law, medicine, or any other field of effort. If the subject is fairly presented in both town and country schools it will attract not only such farmers' sons and daughters as are suited to farm life, but other children whose talents lie in this direction. Whether one ever engages in farming or not, his sympathies and outlook in life and his usefulness as a citizen will be vastly broadened by a well-planned study of the problems of agriculture.

Before one begins to teach agriculture or any other subject, he should get a clear idea of the ends to be attained in teaching that subject. With no definite end in view, one

wanders aimlessly about, arriving nowhere. With wrong conceptions of the aim of the course, the teacher may greatly injure the minds of the children he is guiding. Is the aim of the school course in agriculture to teach children certain facts and principles concerning farming and to have them gain a certain amount of skill in farm operations? Undoubtedly it is; but this is not all. Those children who will be farmers will be something else besides; they will be human beings with rich and varied mental capacities that need exercise and opportunity to develop. In a word, the farmer is a man, and his course in agriculture should not only teach him about farming operations, but such subject-matter should be selected, and such methods employed in teaching, that, while he learns his agriculture, he learns also to use effectively his mental and moral powers, and to understand better his relation to his neighbors, to nature, and to the Author of nature.

As an inheritance of the Middle Ages, men held for many centuries the absurd idea that man's greatest powers, such as imagining, conceiving, generalizing, and reasoning, were best trained when studying a certain small set of subjects that had no immediate, practical application in life, such as ancient languages and formal logic. The fact that in the study of a certain subject the truths learned or the skill acquired had such application seemed in their eyes to take away from the study its power to broaden the mind. For this reason certain subjects were spoken of as giving culture, and others that gave immediately practical knowledge were supposed to give no culture, or even to be opposed to culture. Now, this is a totally false way of looking at the matter. The fact that knowledge is, or is not, of immediate use

is not what determines its value in cultivating and broadening a child's mind. The essential question is, Does the knowledge in question broaden his sympathies, refine his taste, develop his imagination and reason, and give him a new tool, new method, or new principle that he can use for further thinking in this or in other fields? Teaching the bare fact that something happened in Rome on a certain date is not giving the child culture, but pointing out the deadly results of animal gratification and of the unworthy use of wealth in Rome teaches a lesson that has applications all through a child's life and is of the highest cultural value. Just so, teaching the child the bare fact that a certain fertilizer is good for cotton, and a certain food good for hogs, has no special cultural value, and may have very little value for his future farming; but helping him to learn how plants and animals grow and are nourished, and to apply these principles to cotton or pig culture, gives him a kind of mental exercise that will help him in all similar problems in life. Moreover, it gives him certain general principles of feeding and of growth that will make his thinking clearer when later he tries to care intelligently for his own body or provide for his family or his nation. It is not the subject you are teaching that determines whether you are cultivating the minds of your pupils, but the character of the subject-matter selected within that subject and the methods employed in teaching it. For this reason great care has been exercised in this book to select those great but simple, far-reaching principles that underlie successful farming and farm life, and to show by concrete observations how these principles apply, instead of teaching merely unrelated facts and concrete methods of doing farm work. Don't require pupils to

memorize all the varieties of cane or milo, or all the sections in which each crop is raised, or the exact numbers of hogs in Iowa, or the exact limits of weights for Tamworths, or other such details. The exact figures and other details are given in the text merely to round out the picture for the child when studying, to give definiteness and to increase interest. It is worse than a waste of the child's time to have him memorize from day to day masses of details which he forgets in less than a week. The needed details regarding a few crops and animals especially important for the neighborhood may be thoroughly mastered and held in mind by reviews.

We would urge the teacher not to be satisfied with merely getting the children to understand the explanations and our illustrations, but always to stimulate them to exercise their own reasoning powers by finding other applications of these principles in their own experience or observation. To help the teacher, we have provided all through the book suggestive questions and problems for the pupils. Insist on the pupils thinking these answers out, or working them out for themselves. Don't tell them the answers, but help them to think for themselves. We have provided also definite observation problems and tests and experiments, so that pupils may get practice in reading and following directions, in observing carefully, in recording accurately their observations, and in drawing rational conclusions. We have carefully selected such problems and experiments as are not beyond the powers of the fifth or sixth grade boy or girl. While it is difficult for children at the beginning to carry out directions carefully, record observations accurately, and reason clearly, most of them soon learn to do these things

if required to do so and if properly encouraged. The exercise of their new power and the recognition of their own new strength give them great pleasure and increase their interest in the work. Each child should have his own note-book, and keep it carefully all through the course. Remember that the children get new power by doing and thinking things out for themselves, and not from the teacher's doing things for them or telling them about what others have done. It takes more time and intelligence on the part of the teacher at first to get the children to do things right themselves, and to think for themselves, than it does to do things for them and think for them; but when the pupils have once learned to think and do for themselves, they progress more and more rapidly as they go, whereas, by the other plan, they get weaker and weaker and need more help as the course advances. A child that has germinated a seed, marked the root and stem according to directions, watched to find out how each grows, and has written a record of his observation, will not only remember the results easily, but will be better able to work out some other new problem for himself; whereas the child that merely reads about how roots and stems grow, or is told about it by the teacher, is likely soon to forget it, and is no more able to work out a new problem at the end of his course than he was at the start.

Again, the course in agriculture should be correlated with the other work of the school. The lessons in agriculture should help the spelling and reading work by requiring correct spelling in the note-books and papers, and by having the children read interesting bulletins and nature poems and literary masterpieces dealing with farm life and the country.

They should help the geography study by arousing interest in such questions as the relation of climate to production, the arithmetic study by sums in farm mathematics, and all science classes by pointing out the practical applications of the principles of these sciences in the daily work of life. In fact, agriculture properly taught enriches and enlivens every other study in the school by helping to connect these with the daily life and daily needs of the pupils. It gives the pupils not only facts and principles that will help them to get greater returns from their labor on the farm, but it starts new lines of interest and opens up to the young minds broad fields for future study in the varied sciences, some of whose principles they have learned to appreciate in their study of agriculture.

It is hardly possible for any average child to work all of the problems, perform all of the experiments, make all of the observations, and write all of the reports suggested in the book. Circumstances and local conditions are so varied that no single set would suit all equally well. The large number given makes it easy to find a set suited to practically any condition. A part of the experiments may be performed by the teacher as demonstrations before the class, part may be omitted when first going through the book and given on the review, thus giving freshness to the work. At times it will be well to assign one part of the problems and observations to one set of pupils, and one to another, and let each report to the whole class. Sometimes it would be best for only one pupil to try out a problem in his home plat and let all observe the results. Other observations and reports are better made by the class as a whole in company with the teacher, especially those demanding visits or rambles over

the neighborhood. It is especially desirable to have the children work on the problems at home. In this home study, free discussion with parents should not only be allowed but encouraged. When strong differences of opinion are developed, do not try to settle the matter by argument, or by assumption of infallibility, but arrange a definite experiment and test the matter in the experimental garden, and have the boy do the same in his home plat. At times parents will not agree with your teachings. This is no reason for worry. Don't set yourself up to know it all, and don't treat your patrons' views with disrespect. State your reasons for your views and then decline to argue, but agree to put the matter to an experimental test. Making such an experiment will be a most valuable lesson for both pupil and parent.

Always encourage the planting of the home patch by each child, and have him carry out in this patch work similar to that done in the school garden, and also larger operations than can well be undertaken in the school garden. The work in agriculture should be a uniting link between the home and the school. The child should carry into the home through his text-book, his home problems, and his home patch all the valuable things that he learns in the school, and the school thus become the centre of interest to which both children and parents look for information and guidance.

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FUNDAMENTALS OF FARMING AND FARM LIFE

CHAPTER I

INTRODUCTORY

1. **Agriculture the Most Important of All Industries.**—Agriculture is the most important of all industries, because it is the one without which none of the others could exist. If the farmer produced no crops everybody would starve, except the few who could live on wild plants and dress in animal skins. If the farmer grew no crops the railroads would have practically nothing to haul, the factories would have practically no material out of which to manufacture their goods, the merchants would have practically nothing to sell, and nobody would have money with which to buy, the lawyers would have no clients who could pay them, and the doctors, preachers, and teachers would all have to starve with the rest or live like the savage. The farmer is the foundation of our civilization, for, when he fails to support them, all the other occupations fall to the ground.

2. **How Agriculture Has Developed.**—Agriculture is almost as old as the human race. The early savage learned first to eat the plants and fruits as they grew wild, and to catch and eat the wild animals. Then he learned to tame and use, that is, to *domesticate* (dō-mĕs′tĭ-kāt), the wild

animals. These herds of domesticated animals were driven from place to place as the food or water supply was used up in one place. Later, man learned to gather the seed of wild plants, and to sow and cultivate patches of those plants that gave him food or clothing. These were planted on one spot till it would no longer yield a good crop, and then the man or tribe moved over to another spot and let the old one grow wild again. This is the way the savage farmed. Next, man learned that, by plowing the weeds and grass under and letting the land rest a year he could again produce a good crop on it. This is called the *bare fallow*. Then man learned that by putting manure on the soil he could continue to get good crops on the same land. Next, it was found that the planting of a certain kind of crop one year would make the land give a bigger yield of some other crop the following year. This is *rotation* (rō-tā′shŭn) of crops. You will learn more about this when you study the lesson on crop rotation. Finally, man found just what the different plants were made of, and

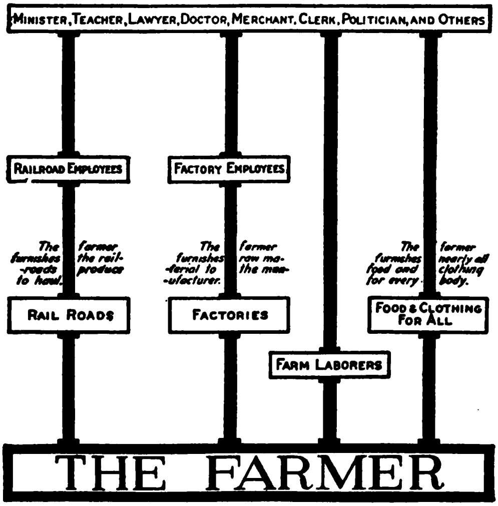

FIG. 2. The farmer sustains all.

learned that the few chemicals that the growing plant takes out of the soil could be gathered from other places on the earth and put into the ground ready for the young plant to use in growing. These chemicals that are put into the ground for the plant to feed on are called *fertilizers*.

3. **Agriculture Enables the Earth to Support More People.**—The earth could support only a few people when all de-

Fig. 3. Numbers 1 and 3 represent the original tomatoes from which our fine modern tomatoes, 2 and 4, have been developed.

pended upon wild plants and animals for food. It could support more when cultivated as the savage cultivated it, or with the bare fallow; after better methods of cultivation, the use of manure, of fertilizers, and of crop rotation had been discovered, it became possible to use all the land year after year, and to support a great many times as many people as could formerly be supported.

4. **Greatest Improvements in Agriculture Have Come in Recent Years.**—While for thousands of years a gradual improvement in agriculture has been going on, there has been an especially rapid improvement during the past hundred years, since farm matters have been studied more carefully. Better kinds of plants and animals have been

FIG. 4. The wooden plow of our early ancestors.
Courtesy of the U. S. Department of Agriculture.

developed, better farm tools invented, better methods of tillage discovered, new ways of killing crop pests learned, better ways of harvesting, preserving, and marketing the crops, and dozens of other things. A good example of the way plants have been improved by study and careful breeding is found in the sugar beet. The best sugar beets in 1812 yielded only eight pounds of sugar per hundred pounds of beets. So much better kinds have been bred that the average for the United States in 1907 was twelve and nine-tenths pounds of sugar per hundred pounds of beets, and an especially fine kind gave twenty-two pounds per hundred.

FIG. 5. The "Oil Pull" Gang Plow which, in a demonstration in 1911, with three engines, did the work of 100 men, 200 horses, and 50 plows, plowing 14 acres an hour at a fuel cost of 6½ cents per acre.
Courtesy of the Oliver Plow Co.

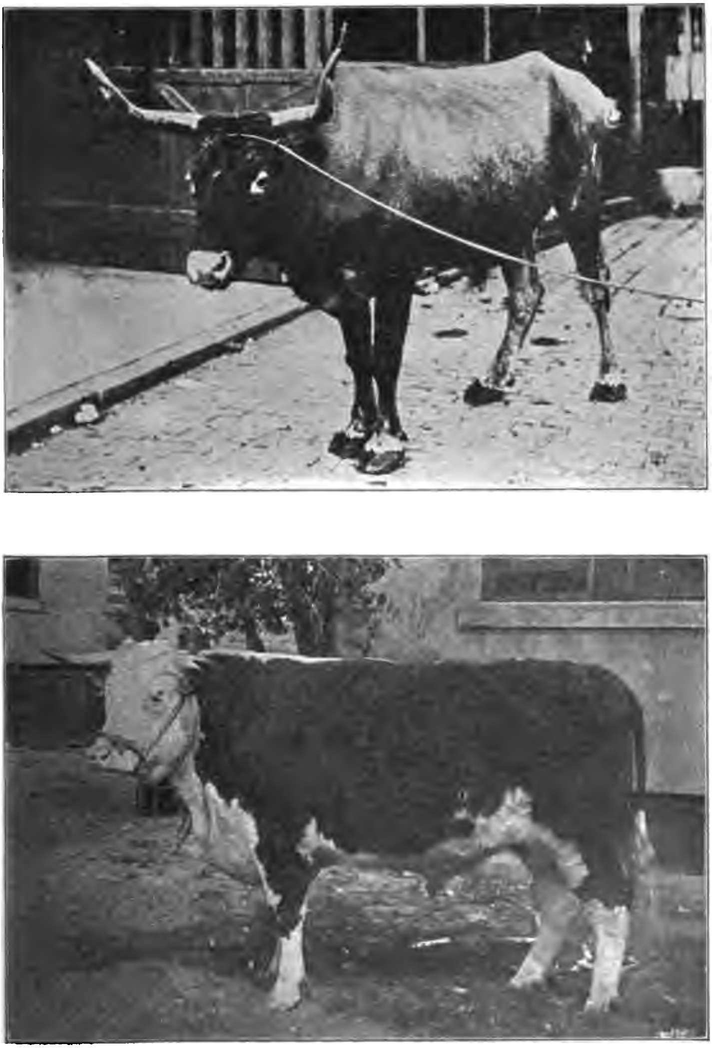

Fig. 6. The old long horn and Prince Welton, champion two-year-old Hereford.

By applying in similar manner to animals the principles of breeding, we have produced the big Durham and Hereford cattle, and the fine Jersey and Holstein cows in place of the little wild scrub stock, and have the fine Poland-China, Duroc-Jersey, and Berkshire hogs that grow as large in six months as the old wild hogs used to grow in six years. The American Indian used to cultivate his crop with a clam shell tied to a pole. The early settlers used a wooden plow. Then the iron plow was invented, then the sulky plow, and finally the great steam plow that opens a dozen furrows at once and at the same time grubs out the brush. Our grandfather thought his new iron plow, with which, by hard labor, he could cultivate an acre a day, was a wonder. Now, his grandson can ride and more easily cultivate fifteen acres a day with his double-row sulky cultivator. By methods used in 1830, it took sixty-four hours of a man's labor to produce an acre of wheat; in 1900 it took just two hours and fifty-eight minutes. Our improved methods and machinery enable one man to cultivate on the farm about what it took five to cultivate in 1850. In the same way the study of the last few years has taught us to stop cutting corn roots by deep plowing, to keep a dust mulch on the ground to hold in the moisture, and scores of other valuable lessons.

5. **Corn Made in Spite of Drought.**—By using newly discovered methods of conserving the moisture in the soil, farmers have raised in west Texas twenty-five bushels of corn per acre with only one-half inch of rainfall from planting to harvest, and forty bushels with one and a half inches of rain. Fifty years ago not a grain of corn could have been produced with that little rain.

6. What You Will Learn in this Course.—As we go on from chapter to chapter, you will learn how these things are done. You will also learn how to use the little *bacteria* (băk-tē′rĭ-ȧ), that are so small you can not see them with the naked eye, to gather plant food out of the air for your

FIG. 7. Jerry Moore, the corn club boy, and part of the 228¾ bushels of corn raised by him on one acre in 1910.

plants, how to make your fields richer and richer each year, how to gather and market your crop to better advantage, how to procure for your farm home the comforts of the city home, with all the quiet joys of the country, too, and you will learn scores of other interesting and helpful things.

7. What Dr. Knapp's Boys Have Done.—Dr. Knapp, the well-known government expert in agriculture who started our demonstration farms, corn clubs, hog clubs, and canning

clubs, says that we can yet make the average yield from our land eight times what it is. This sounds impossible, but it is not. Right at the start, the farmers on Dr. Knapp's demonstration farms, by using better methods, are reported to have raised on the average in 1911 85 per cent more cotton and 93 per cent more corn per acre than their neighbors made. The little corn club boys also have learned how to beat their fathers raising corn. Jerry Moore, a South Carolina boy, raised 228¾ bushels on one acre; an eleven-year-old Missouri boy raised 222 bushels, and an Alabama boy 212 bushels. In 1911 in Louisiana ten boys raised an average of 120½ bushels of corn to the acre, at an average cost of 19 cents per bushel, with an average profit of $67.70 per acre. One boy produced 150¾ bushels to the acre, at a cost of 16$\frac{8}{10}$ cents a bushel. Ira Smith, in Arkansas, raised 119 bushels on an acre, at a cost of only 8 cents a bushel; and Floyd Gaynor, a fifteen-year-old Oklahoma boy, raised 95 bushels to the acre, at a cost of 8 cents a bushel. That year was an extraordinarily hard year for corn in Texas, many old and successful farmers not raising an ear; yet thirty-one of Dr. Knapp's boys in west Texas produced an average of 60 bushels per acre, at an average cost of 24 cents a bushel. Sixty-five Texas boys raised over 50 bushels to the acre, and eleven-year-old Johnnie Bryant raised 114 bushels.

8. **What You Can Do.**—What has been done by a few in corn raising can be done by every intelligent boy, not only with corn, but with all other crops. But to do this you must learn the secrets of nature, how plants grow, how they feed themselves from soil and air, how they are bred and improved, how to protect them from their enemies, how to

use labor-saving tools and devices, how to improve your soil from year to year, how to keep your stock strong and healthy, how to keep your farm home attractive and keep yourselves healthy, happy, and eager for work, how to gather and market your crops, and how to keep your farm accounts so that you will know just which crops pay best for your labor and time. To learn everything about all of these is the work of a lifetime, or many lifetimes, but in this first course you will learn the most important facts and general principles, and will learn how to study these farm problems for yourselves in the future.

QUESTIONS, PROBLEMS, AND EXERCISES

1. Do you know any one who farms now the way the savage farmed?
2. Give an account of some one in your neighborhood who has used the bare fallow. Can you find out how much was produced on the land the year before the fallow, and how much the year following?
3. Can you give an actual case of manuring land, and tell how much manure per acre was used, and what increase it produced in the crop? (Be sure that the manure caused the increase. How could you make sure that the manure caused the increase?)
4. Give an actual case of some one who practises rotation, and tell what crops make up the rotation. Can you get any figures showing how much the rotation helped the land?
5. If a farmer had more land than he could use, what would he gain by raising fifty bushels of corn on one acre rather than twenty-five bushels per acre on two acres?
6. Name all the ways in which the people would have to get food and clothing if all the farms failed entirely for a year.

CHAPTER II

PLANT GROWTH

9. **What We Are to Learn.**—You have now seen some of the wonderful advances that have been made in agriculture, and learned that still greater improvements can yet be made. This past progress was made possible by first learning how plants grew, how they got their food, and how they multiplied, how they were improved by breeding, how they were affected by favorable and unfavorable conditions, and so on. Let us now learn these laws of plant growth ourselves. Then we shall understand the reasons for doing the things we now do in raising our crops, and shall be able to think out still better methods in the future. In this chapter you will learn how the plant starts from the little seed, how it gets strength to burst its coat, how it gets food materials from the earth and from the air, how it forms its different parts, and how each of these parts helps the plant in its growing, how the roots take the crude food materials from the soil, how this food material is carried through the stem up to the leaves, how it is made into plant food in the leaves and other parts of the plant, so that it can be used by the plant in building more plant substance, and then how the prepared food is distributed to all parts of the plant. We shall also learn how the plant produces a new seed or a new plant, and how we can by breeding and selection make this new plant different from and better than the old one.

10. The Seed.—As most farm plants are raised from seed, let us begin with the seed. Many so-called seeds are not simply seeds, but are fruits, or parts of fruits, containing one or more seeds. The so-called seeds vary in many ways. Some are large as an egg, such as the alligator-pear's; others

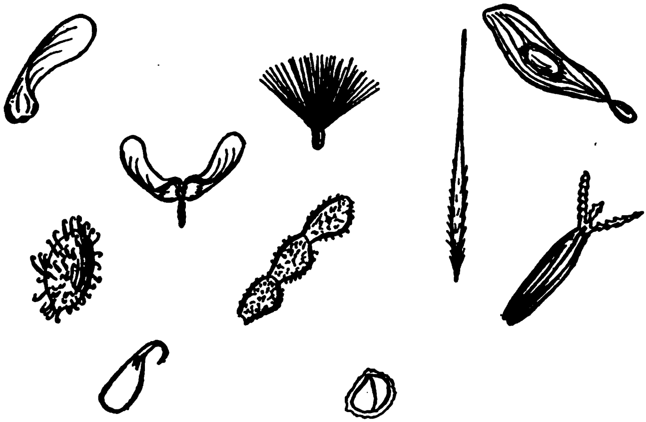

FIG. 8. Different types of so-called seeds, which are in reality true seeds with parts of the fruit adhering.

are smaller than the mustard-seed; some are encased in hard shells and hulls, like the hickory-nut; others are inclosed in soft pulpy substance like the orange-seed; some have soft down on them and float in the air, like the thistle-seed; while others have sharp spines like the cocklebur or the beggar-louse. But all seeds serve the same purpose of producing the new plant, and all true seeds are made up of three distinct parts. There is, first, an outside coat or seed-case, usually thin and tough, which protects the parts inside. Second, there is the little *embryo* (ĕm′brĭ-ō). The embryo is the new plant itself, often showing plainly begin-

nings of a stem, leaf or leaves (called *plu-mule*), and root (called *rad-i-cle*). Third, there is a small mass of highly concentrated food, on which the embryo must feed till it can grow roots and leaves strong enough to gather its own food materials directly from the earth and air, and manufacture them into plant food. This *reserve food,* as it is called, is made up chiefly of starch, sugar, protein, and oil, in varying proportions, and is the main part of the nuts and grains that we eat. In the pecan, it is the rich oily meat of the nut; in corn and wheat it is the white starchy part of the grain that makes our flour and meal. We also eat the little embryo. This embryo is easy to see in corn, where we call it the germ.

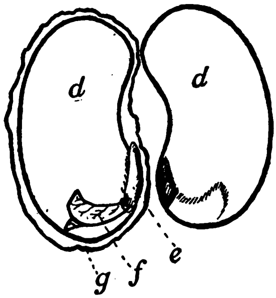

FIG. 9. An opened bean-seed that has been soaked till the seed-case has softened and the seed begun to germinate. *d* is the cotyledon; *e* is the sprouting radicle; *f* is the plumule; *g* is the loosened seed-case.

11. The Seed is Alive.—The dry, lifeless-looking seed is not a lifeless thing, like a chip of wood; but its living germ will never grow till the right conditions for its growth are

FIG. 10. This shows a seed germinator made of two plates and two layers of canton flannel or of blotting-paper. The cloth or paper is moistened thoroughly and the seeds laid between the folds. Then this is placed in one dish, a little water is added, and the other dish or a pane of glass used to cover and prevent evaporation. On the right is shown a modification of this, made by inverting one deep dish in another containing water and then placing the seeds between folds of a cloth which is placed on the bottom of the inverted dish in such manner as to allow the edges of the cloth to hang down in the water.

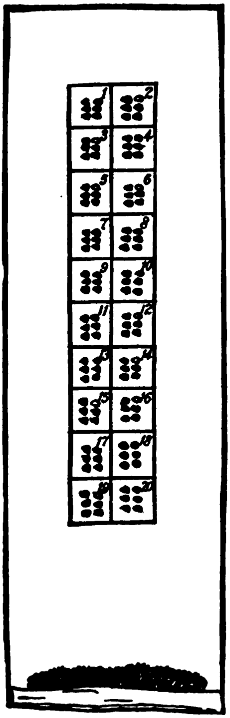

FIG. 11. The rag-doll germinator, consisting of a piece of canton flannel with a number of little squares, usually two or three inches square, marked on it with indelible ink or pencil, and each numbered. This is first moistened thoroughly, the seeds are laid on the squares, a record is made of what is on each square, and then the whole cloth rolled up, beginning with the darkly shaded part at the bottom. The shading represents a damp sponge or rag, placed there to make the roll larger and easier to roll. When rolled up, the end of the "doll" is placed in a vessel of water, so that the cloth will soak up a constant supply of moisture for the seeds.

supplied to it. In this state in which it is alive, but not active, it is called *dormant* (dôr′mant). When the right conditions for growth are supplied the seed, it becomes active and begins to grow. The first growth is called *germination* (jĕr-mĭ-nā′shŭn).

12. **What Starts the Seed to Growing.**—Take a few seeds of the bean or other common plant and place them in a seed germinator. In from six to twelve hours you will notice that the beans have absorbed some water and increased in size. In a short time the seed-case bursts and a white sprout appears, which is the beginning of the new *plantlet*, or little plant. The seed has now begun to germinate. Let us see under what conditions a seed will germinate, and under what conditions it will not germinate; then we shall know what conditions to provide in the soil when we plant seeds. We can make three experiments and find out for ourselves what makes a seed germinate.

13. **First Experiment.** — Place six beans in a can of moist soil and keep it moist for a few days. Place six in a can of perfectly dry soil and keep it dry. When the beans in the moist soil have germinated, dig up those in the

dry soil and see what they have done. If you find that the beans in the dry soil have not germinated, and those in the moist have, what does this show about water being necessary for germination? If seeds must have moisture in

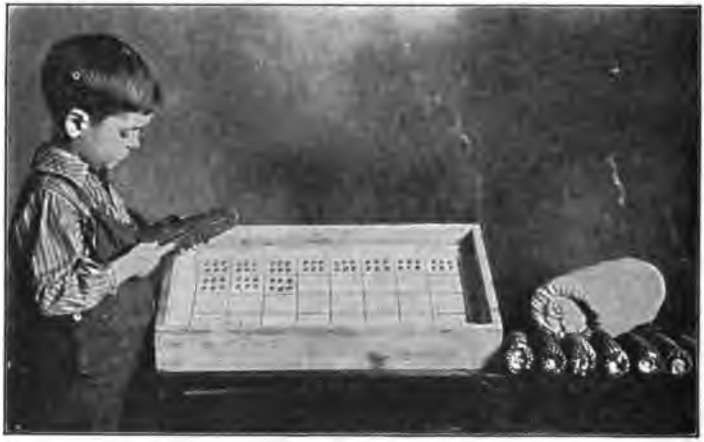

Fig. 12. The sand-box germinator, which consists of a box about four inches deep with holes in the bottom for the escape of water. This is filled half full of sand or sawdust and a cloth is laid over this and marked into squares. The seeds are placed on these squares and covered first with a cloth the size of the box and then with a cloth which is made large enough to extend above the top of the box all around. Then the box is filled with sand or sawdust, thoroughly watered and kept moist. When it is time to examine the seeds, the covering is lifted off by raising the top cloth without disturbing the seeds. If it is not desired to examine the seeds, but merely to see how well they germinate, the cloths are not necessary. In this case the box is laid off in squares by means of string tacked across the top. In cool weather the box may be made eight inches deep and filled with four inches of horse dung and then the sand placed on top of this. The manure serves to keep the box warm.

Courtesy of the Department of Agriculture, University of Minnesota.

order to germinate, then what must the farmer watch for and get his land and seeds ready for, so that he can make use of it when it comes? In the chapter on the soil, you will learn how to cultivate your land so as to hold the moisture in it for weeks, and by winter and early spring plough-

ing make it possible for your seeds to germinate even if no rain should come at the planting season.

14. **Second Experiment.**—Take two cans two-thirds full of fresh water and boil one can for ten minutes, and in this way drive out all the little particles of air that are naturally in the water. Then pour oil on top of this can of boiled water till the water is covered with oil about an eighth of an inch thick. This film of oil will prevent any air getting down into the boiled water again. Now place some seeds of rice or water-cress in the can of boiled and oil-covered water that has no air in it, and the same kind of seeds in the other can of water that has not had the air boiled out of it. Watch these seeds for several days and see which ones begin to germinate. If you find that the seeds in the water that had the air boiled out of it have not started to germinate, while those in the water with the air still mixed in it have begun to germinate, what does that show to be necessary besides water to make seeds germinate? Beans, corn, and most other farm plants require more air for germination than is present even in fresh water. This being true, what would happen to these seeds if immediately after being planted such a long hard rain fell that the free air was all packed out of the soil, and the soil so filled with water that no more air could get down to the seeds? Ask at home if that has ever happened on your farm.

15. **Third Experiment.**—Take two cans of moist soil and plant six beans in each. Put one of these where it will keep warm day and night, with a temperature of 60 to 80 degrees, and place the other in the refrigerator at home, or out-of-doors where it will be kept cold, with a temperature near freezing. After three or four days examine the seeds

in both cans and see if both are sprouting alike. If you should find that the beans in the warm soil had begun to sprout, and those in the cold soil had not, what would this show to be necessary for the germination besides moisture and air? If seeds are planted in spring when the ground is still cold, what will happen? If, later in spring, after the ground is warm and seeds are planted, there should come a long, cold, rainy spell, what would happen? If the cold weather lasted very long after the seeds were planted, what would probably happen before they got a chance to germinate? Has this ever happened on your farm?

16. **Differences in Seeds.**—There are great differences in seeds. Some require a very warm seed bed to germinate, such as cotton, while others, such as oats or rescue-grass, can germinate with much less heat. Some seeds require also less moisture and less air than others do. If the cold is not too great, many seeds will germinate in cool weather, but do it more slowly than when warm. Beet seeds that germinated in three days at a temperature of sixty-five degrees, took twenty-two days to germinate at a temperature of forty-one degrees.

17. **How Roots Grow.**—When your bean-seed has got the necessary amount of heat and air and water to germinate, you will see that it first swells, and then a tiny white sprout bursts out of the hull between the two divisions of the bean. This little white sprout is called the *radicle* (rădĭ′-kl). The word radicle is made from the Latin word *radicula,* which means a little root. As soon as it gets out of the seed-coat, the radicle turns down and makes its way into the moist soil to form the root of the plant. This root must gather food material from the soil for the young plant,

or the plant will starve as soon as it has used all the reserve food in the seed. If there is no moisture in the soil, the root can get no food materials from that source, for plants, like babies, can take in only liquids. If the ground is packed so hard that the tender radicle cannot force its way among the soil particles and come in contact with the little films of water covering these soil particles, then the plant can get no food materials and must die, or can get so little that it cannot grow. What does this show us that we must do to all seed beds before the seeds are sown, if we wish the young plants to grow? If the soil is not too hard, this radicle grows on down into it and makes the main root, or *tap-root,* as it is called, while upon its sides grow the branching roots called *lateral* (lăt′-ĕr-ăl) roots. Lateral is also from an old Latin word, *latus,* which means the side. From the sides of both the main root and the lateral roots grow out thousands of little fine *root hairs.*

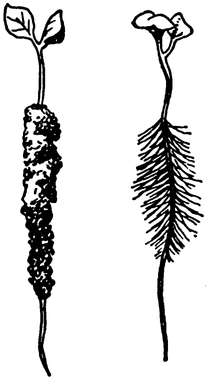

FIG. 13. The root hairs on a young radish-plant. The drawing on the left shows the soil still adhering to the hairs.

18. **What Roots Do.**—Neither the tap-root nor lateral roots are able to take in any food material directly from the soil, but serve to hold the plants steady and give a large surface from which root hairs may grow out. These tiny root hairs grow out from the new growth of both the tap-root and laterals. Some of these hairs are too small to be seen with the naked eye, there being in some cases nearly forty thousand growing out from a square inch of root surface. These are so tender that they are usu-

ally torn off when we pull a plant out of the ground, but you can see them easily if you will germinate corn or oats in a germinating-dish. Figure 13 shows the mass of root hairs on the roots of a young radish-plant. It is

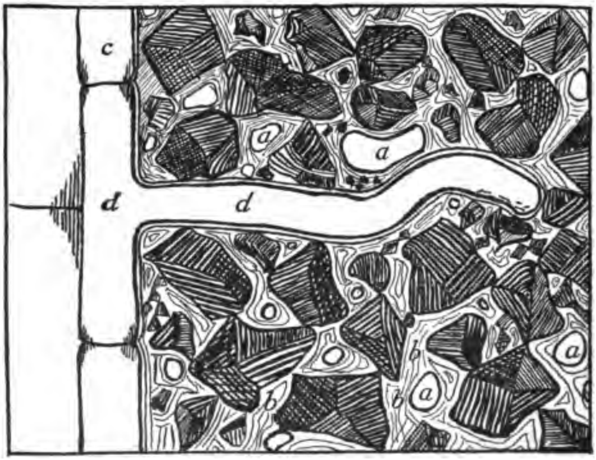

Fig. 14. The root hair (*d*) penetrating the soil, as seen under the microscope. Note the black soil particles with the films of water (*b*) surrounding them. Also note the air spaces (*a*) among the soil particles. Note that the root hair is a continuation of a single cell in the outer membrane of the root.

through these soft root hairs that the plant takes in all the food material it gets from the soil. These hairs reach out between the particles of soil and absorb through their skin-like covering the water and various kinds of food materials that are dissolved in the water that is in the soil. This raw, unprepared liquid food material then passes through the root hairs into the roots and on through the stem up to the leaves to be prepared, so that the plant can make it into its own substance.

19. How Root Hairs Take Food Materials.—The process by which the thin membrane of the root hair, which has no mouths or holes in it, lets the liquid food material come into the root is very remarkable. You can see this same process going on if you will take a lamp chimney and tie a piece of well-washed and softened bladder over the end, or, better still, take a tube shaped like the one in Figure 16 and tie the bladder tightly with a waxed thread over the large end of this, so that it will hold liquid when poured into it. Then pour into the chimney, or tube, either molasses or strong brine till it is half full or more. Then fasten the chimney in a jar or large bottle of fresh water, so that the water in the jar is just level with the molasses or salt solution in the tube. Leave this for an

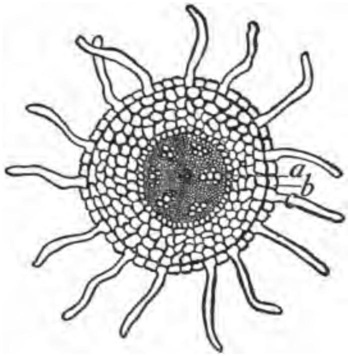

FIG. 15. The cross-section of a small root as it appears under the microscope. Note the root hairs (*c*), the epidermal cells (*b*), and the fibro-vascular bundles (*a*) through which the liquid plant-food materials pass up to the stem and on to the leaves,

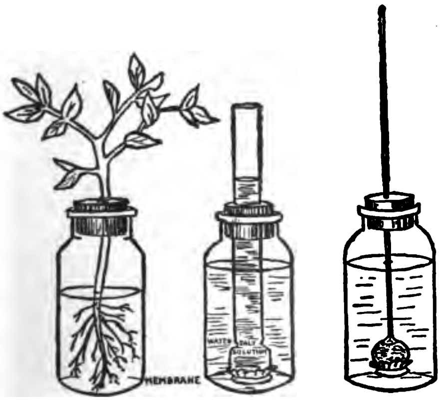

FIG. 16. An easy method of studying the working of osmosis. The dilute liquid in the outer vessels passes into the stronger solution in the inner vessels in the same way that the soil water passes into the root hairs of the plant.

hour and see if the liquid inside the tube has not risen higher than the water level in the bottle. If it does this, does that show that some of the water from the bottle has passed through the bladder into the tube and increased the amount of the fluid there? This passing of a liquid through a membrane is called *osmosis* (ŏs-mō′sĭs). It is by this process of osmosis that the tiny thread-like root hairs take in all the food materials that the plant gets from the ground. You see that the plant can take in only such food material as is in liquid form dissolved in water in the ground. When all the water is dried out of the ground, then the plant is not merely unable to get any water, but is unable to get what else?

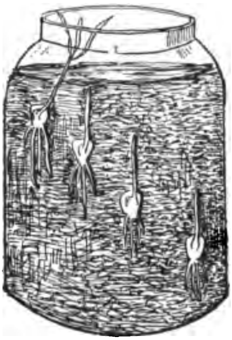

FIG. 17. Shows the method of planting seeds at different depths in such way that their growth may be watched.

20. **How the Plant Gets Its First Food.**—We have seen now how the little radicle bursts out of the seed, grows down into the earth, forms the main tap-root, and throws out lateral roots, and how the tiny root hairs develop on the new parts of all roots, grow out among the soil particles, and soak up liquid food material and send it back into the roots. Now let us see next what the other parts of the seed are doing while all this is going on. Let us see how the plant gets ready a stem and branches and leaves to receive the crude food materials gathered by the roots, manufacture these into true plant foods, and distribute this food to all parts of the plant.

21. **Reserve Food of Plants.**—If you will watch a bean-seed growing in the soil, you will see that soon after the point

of the little radicle begins growing downward, the other end of the germ, which is called the *plumule* (plū′mūl) begins to grow upward and to drag along with it the two large parts of the bean, which look at first as if they are thick fat leaves. These two thick oval pieces are sometimes called seed leaves. They do not, however, behave like green leaves, but are full of concentrated food, which was manufactured and placed in the seed by the parent plant. This food reserve supplies the germinating plant with nourishment until it can develop the root hairs, stem, and leaves to gather food materials and manufacture its own food. These thick leaf-like pads of food are called *cotyledons* (kŏt-ĭ-lē′dŭns). All seeds have this reserve food in them, but all do not have the two cotyledons, nor do all plants draw them through the soil when sprouting, as do the beans. The grains and many others have only one package of reserve food. A few plants have more than two cotyledons. Sometimes this reserve food, instead of being inclosed within a part of the embryo, is attached to the embryo, or may even merely surround it. As the plumule of the bean grows upward into a stem and the tiny leaves unfold and grow, you will notice that the cotyledons

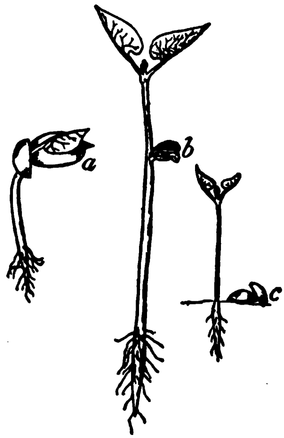

FIG. 18. A young bean-plant just coming up with cotyledons (*a*) thick and full of reserve food. In the centre the same plant a few days later is shown with cotyledons (*b*) empty of food and wrinkled. On the right is a young plant that has been stunted in its growth by the removal of the cotyledons too early, thus depriving it of its reserve food.

get thinner and thinner, and after several days shrivel up, and after a week or so more fall off. Can you see why this happens?

22. **How the Plant Develops Stem, Branches, and Leaves.** —The way the stem of this young plant, or *seedling*, as it is called, grows is interesting. If you will take a bean that is just out of the ground, or one that has just begun to grow in the germinator, and will put marks in water-proof ink every eighth of an inch along the stem, and then look at these same marks twenty-four to forty-eight hours afterward, you will see that some parts of this stem are growing much faster than others. The most rapidly growing part is just behind the tip and is called the *growing point*. The stem elongates most rapidly just back of the growing point. This growing point grows rapidly upward, forming the stem, and soon leaves and branches bud out on the side. These side branches are called lateral branches. The bud on the end is called the *terminal* (tẽr′mĭ-nal) bud. This word terminal is made from another Latin word, *terminus*, which means the end. If you will open up carefully and examine the growing tips of main stems and laterals of some woody plant, you will see that on the outside there are close-fitting scale-like modified leaves, called *bud scales*, which protect the tender growing point and the tiny undeveloped leaves within. As these leaves begin to grow and the growing point pushes out, the protecting scales are burst, and the new leaf or leaves unfold and grow, while the growing point pushes on. With *herbaceous* (hẽr-

FIG. 19. A woody stem with the terminal bud and several lateral buds.

bā'shŭs) plants like the bean, the growth is similar, except that there are no protecting bud scales.

23. **Peculiar Ways of Growing.**—Each variety of plant has its own peculiar way of growing; some stems stand erect, as the oak; some lean on other things, as does the grapevine, and some lie flat on the ground, as do the melon vines. Some send out leaves and branches in pairs, opposite each other, at regular intervals along the stem; some have their leaves come out singly, first on one side and then on the other side of the stem and branches; some come out on all sides at the same level, and some in yet other ways. Why some plants always act one way, and others another, we do not as yet fully understand. That question is not important for us; but why any plant grows at all, and just how it manages to do so, is most important to know if we expect ever to grow crops. In order to understand how the stem can elongate and throw out these leaves, we must look inside the plant and see first how it is constructed and just how it gets its food and makes out of it the new leaves, stem, branches, and other things. By studying this one step at a time it will soon all be plain.

24. **How the Plant Gets Crude Food Material.**—You know now that the bean has leaves, branches, stem, roots, and root hairs. Practically all plants dealt with on the farm have these same parts. Each part has its own work to do for the good of the whole plant, including itself. We are now ready to see how each of these parts of the plant helps the plant to get food and grow. You will remember that the roots are covered with root hairs, which by osmosis take in the food materials that are dissolved in the water in the ground. In addition to this, these root hairs, by the

small amount of acid that they give out, dissolve some of the substance of the soil itself, which is then taken up by the water present and absorbed by the root hair. The whole plant is made up of a mass of small cells similar to the root-hair cells, in having a membrane surrounding them, but differing from each other in size, shape, and other ways. The liquid food material, once inside the root-hair cell, passes on into the adjoining cells by osmosis through the cell membrane, just as it passed from the soil to the root hair. From these root cells it is passed through tiny tubes extending in sections up through the stem and branches out into the ribs and veins of the leaves, and finally is spread out into all the tissues of the leaf. The leaf is a wonderful kitchen and chemical laboratory combined for the plant. Here in the leaf the plant does some things that no man has yet been intelligent enough to learn how to do. Here the crude food material that is drawn up from the soil through the root hairs, roots, and stem is mixed with other material taken from the air, and new foods are made that are sent back all over the plant to build up its tissues and to store reserve food. A little later we shall look at the structure of the stem and see by what means it carries the sap back and forth, up and down the plant at the same time.

25. **What Crude Food Material is Made Of.**—Let us now see what the crude food material is made of, what it is changed into in the leaves, and how this is done. The raw food material that comes up from the roots is in large part water, and that taken in by the leaves is a gas that is free in the air. The plant manufactures its food mainly out of water and this free gas which is called *carbon dioxide* (kär′bŏn dī-ŏks′ĭd). The plant, however, cannot live on these alone.

Dissolved in the water taken in by the plant are a number of different food materials. If this food material were not dissolved in a liquid form, it could not pass through the roots and stem up to the leaves to be made into foods and then pass back over the entire plant to feed all the parts as it does. There are just a few of these substances in the soil that plants make their foods from, and all plants and animals use practically the same ones, but in different combinations and proportions. You will learn the names of these in your lessons on the soil. When the crude food material reaches the leaves, a part of the water is used by the plant in making the plant food, which is later made into new plant substance. The larger part passes out of the plant in the form of vapor, mainly through openings in the leaf. This giving off of water vapor by the plant is called *transpiration* (trăn-spĭ-rā'shŭn).

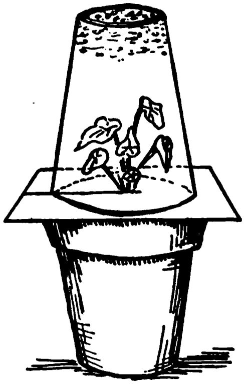

Fig. 20. An easy method of catching some of the water transpired by the plant. The card-board is slitted and fitted closely around the plant, and then the glass is turned over the plant so that very little of the water vapor given off by the plant can escape. Soon the air is so saturated with this transpired water vapor that it is deposited in drops on the inside of the glass.

26. **How the Plant Gives Off Water.**—Transpiration goes on all the time, but most rapidly when the air is dry and the sun is shining on the leaf. You can catch some of the water transpired by a plant if you will follow the directions given under Figure 20. In Figure 21 you can see the structure of a leaf as it appears under the microscope, and can see the openings through which the greater part of the water

passes out of the leaf. The amount of water passed off from a plant is surprising. In this way a full-grown apple-tree will give off about two hundred and fifty pounds of water in a day, or over thirty-five thousand pounds during one growing season. From three hundred to five hundred pounds of

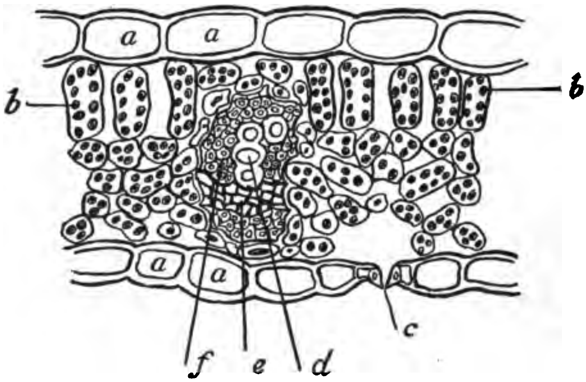

FIG. 21. A cross-section of a leaf as it would look under the microscope. Note (1) the outside layer of epidermal cells (*a*) on top and bottom; (2) the stoma (*c*) through which the water vapor mainly passes off and the air passes in; (3) the green chlorophyl bodies (*b*); (4) the water-tubes (*d*) through which the crude food materials come up; and (5) the phloem (*f*) through which the digested food passes back over the plant.

water pass through and out of the ordinary plant for every pound of dry matter left in it. Of the material left in the growing plant, very little is solid matter. Often as much as nine-tenths is still water. This is why green plants weigh so much more than dried ones do. Corn, for example, at roasting-ear season is over eighty per cent water.

27. **How the Plant Makes Starch and Sugar.**—While the excess water is being transpired out of the leaf, the leaf is taking in from the air the carbon-dioxide gas, one part of

which supplies the material that will make up fully half of the solid matter of the plant. This material is *carbon,* which we can see left as charcoal when wood is burned without sufficient air. All this solid carbon then comes out of the air in the form of a gas and not from the soil at all.* The leaf has special little openings through which to take in the carbon dioxide and give off water. These are mainly on the under side of the leaf, and are so small that the naked eye cannot see them. Figure 21 shows you how these look under a microscope. They are called *stomates* (stō'māts), or *stomata* (stō'mä-tä). One of them is called a *stoma* (stō'mä), which is an old Greek word meaning mouth. The under side of an apple leaf has more than one hundred thousand of these stomata to each square inch. When this carbon dioxide from the air comes into the leaf it is united there with the water brought up from the roots. Water is made up of two substances, called hydrogen and oxygen. When this water is united with the carbon of the air, it makes a new compound of carbon, hydrogen, and oxygen, called a *carbohydrate* (kär-bō-hī'drāt). The two

* It may puzzle you to see how an invisible gas can contain a solid thing like carbon, but, if you will remember what you know about water, you will see that the same substance can exist in the form of either a gas, a liquid, or a solid. Cool water below thirty-two degrees and it becomes a solid called ice. Heat it above 212 degrees and it becomes a gas called steam. If you could run a strong current of electricity through a vessel of water, you would see that this liquid could be broken up into two gases, one called *oxygen* (ŏks'ĭ-jĕn) and the other called *hydrogen* (hī'drȯ-jĕn). In like manner the chemist can put two gases, hydrogen and oxygen, together in the proper manner and form a liquid—water. You see, then, that the same substance may exist as a liquid, a solid, or a gas; and, out of a liquid compound a gas may be taken, or out of a gaseous compound a solid may be taken. Such changes and such making and breaking up of compounds are going on constantly in nature.

important carbohydrates made in the leaf by uniting the carbon from the air with the hydrogen and oxygen brought up in the form of water from the soil are starch and sugar.

28. **The Plant Both Makes and Digests its Food.**—This making of starch and sugar by the plant out of carbon, hydrogen, and oxygen is quite a different thing from digestion of foods by men and other animals. It is not digestion at all, but manufacture of food. This manufacturing of foods no animal can do. Man and all animals are dependent upon the plants for the manufacturing of all their foods. We eat these prepared foods when we eat plants or eat animals that live on plants. Then we have to digest these prepared foods. The plant can manufacture its own foods from the crude food materials in the soil and air, and then later it, too, has to digest this food before it can turn it into new plant substance, in a way very similar to that by which man digests these same foods.

29. **How the Plant Turns Starch into Sugar.**—In most plants the main part of these carbohydrates in the leaf first appears in the form of little starch grains, but as these cannot be dissolved in water they cannot be taken up in the sap and passed back from the leaf down the stem into the roots and other parts of the plant to feed it. The leaf then has to digest this starch, or turn it into a form in which it can be dissolved in the sap of the plant and passed around, just as we have to digest food in our stomach and intestines before it can pass into our blood and be carried in our blood over our body to feed every part. The starch is therefore now turned into sugar, which is dissolved by the watery sap in the leaf. In this form it is passed back along through

the inner bark down the stem and branches to every part of the plant.

30. **How the Plant Uses Carbohydrates.**—This sugar food is used in many ways by the plant. Some is later changed back into starch, some is modified by the addition or subtraction of certain things and made into oil, and into another very important set of compounds which we shall study later. A part of these products are used by the plant in growing, in building new buds, leaves, stem, and roots; a part is deposited in seed as reserve food to start a new set of plants growing; and a part is deposited as reserve food within the plant itself for future use. The peach-trees, for instance, must deposit each year enough reserve food to support them next spring, while putting out their blossoms and getting their leaves started and developed enough to commence again the manufacture of food out of the raw food materials sent up in the sap from the roots. You can often taste the plant sugar in the sap that is passing down the inner bark of a tree. It is this sweet sap of the maple-tree that is caught and boiled down to make maple-syrup and maple-sugar. The tuber of the potato is largely a mass of reserve starch, put there by the plant for future use.

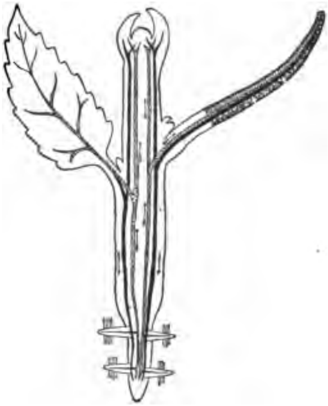

FIG. 22. A very much simplified diagram to illustrate roughly how the crude food materials are carried up the layer of outer new wood, and the digested plant food is brought back down the phloem just outside the cambium layer. Adapted from Stevens's "Introduction to Botany."

This shows very briefly and incompletely the way the plant takes its raw liquid food material from the soil, passes it up the stem to the leaves, and there adds material taken from the air and makes up new compounds which are dissolved again in the sap and passed back down the stem and around to every part of the plant. To tell all the details of the work done by the plant in getting its food would take a long time and confuse your mind now. All of this you can learn later. There are just two more very important points that you should know more about now: first, that there is a special substance in the leaf that helps to make the starch and sugar for the plant; and second, what that other very important set of food compounds is which the plant makes. These two things we shall now learn about.

31. **How Leaf Green Helps the Plant Manufacture Food.** —In Figure 21 you will see that the leaf has within its cells some little bodies called *chlorophyl* (klō′rŏ-fĭl) bodies. When exposed to sunlight these bodies develop in them a green substance called chlorophyl. It is this which gives the green color to the leaves. If the plant gets no light, this chlorophyl does not develop. That is why plants grown out of the light are pale. It is the action of this chlorophyl and the sunlight which splits the water and the carbon dioxide to pieces in the leaf, and makes possible the formation of the new compound, the carbohydrate, out of the carbon, hydrogen, and oxygen set free. Without chlorophyl and sunlight, then, the ordinary plant could manufacture no carbohydrate. As we shall see later that all other plant foods are made by changing or adding to these carbohydrates, it is plain that the whole growth of the plant is dependent upon this action of the chlorophyl and sun-

light in the leaves. There are certain plants that have other ways of getting carbohydrates, and all plants can make a little in green parts outside their leaves, but the ordinary farm plant gets practically all its carbohydrates from the action of sunlight and chlorophyl in the leaves.

32. **How the Plant Builds New Living Substance.**—While the chlorophyl bodies are helping part of the carbon taken from the air by the leaf to join with the water and make carbohydrates for the plant, a part of these carbohydrates is being combined with a substance called *nitrogen* (nī′trŏ-jĕn) and some of the other substances that we saw are also in the sap which comes up from the roots. The new compound which is made by this process is called *protein* (prō′tē-ĭn). There are many kinds of proteins, made in different parts of different plants. This protein is carried along with the carbohydrates in the sap to all parts of the plant, and helps to nourish the plant *protoplasm* (prō′to-plăzm), which is found in every living part of the plant. Protoplasm is the most wonderful substance in the world, for it is the basis of all plant and animal life. When the plant is growing, the protoplasm is in an active state; when the plant is dormant, the protoplasm is still there, but it is not active. When the parent plant forms a seed, a small portion of the protoplasm of the old plant goes into the seed. When the seed germinates and grows, this protoplasm grows; and whenever a cell of the plant divides and thus forms a new cell, the protoplasm in the old cell divides and part goes into the new cell. If it did not do this, the new cell could not live. This protoplasm likewise cannot live and continue to grow in the cells unless the plant has protein. Thus, you see, the plant cannot live without nitrogen and the other sub-

stances brought up from the soil. If you will strip the green bark from a tree or bush and run your hand over the inside of the bark, you will feel the thin, slippery film which is a mixture of sap and protoplasm that is spilled from the broken cells there.

FIG. 23. A quarter of the stem of a tree. Some of the details are exaggerated for the sake of clearness. *a* represents the rough dead outer bark, *b* the dead fibrous inner bark, and *c* the cambium layer. The phloem is not represented, but is just outside the cambium and on the inner surface of *b*; *d* represents the layer of new wood, and *f* the numerous annular rings of old wood. The medullary rays going from the centre to the bark are not plain, though traces of them are seen, especially at *e*.

33. **The Layers of the Stem.**—We have seen that raw liquid food material is passed up the stem to the leaves, that it is then mixed with the raw food material taken from the air, and then this newly prepared food is passed back down the stem and out to the various parts of the plant. Let us now see how the stem is constructed so as to make possible this process. Figure 23 shows you one-fourth of the stem of a tree cut crosswise. You will notice that first on the very outside of the stem is a hard outer bark (*a*), and at the centre are rings of hardwood (*f*). The hard outer bark is dead, and the central hardwood has practically no share in carrying the sap. The tough outer bark serves to protect the delicate inner bark, and the dense hard centre, or heart, of the tree serves mainly to strengthen the stem so that it can hold the great masses of leaves and young branches up to catch sunlight and air. At one time this heart wood was composed of active cells through which

the sap passed, but as the plant became older these cells became clogged with various substances which rendered them inactive. Often you can see a tree in which this central part has become diseased and rotted away, leaving only the bark and the new outer part of the growing wood standing. Such trees may continue to grow, because the layers that pass the food supply up and down the tree are still active. Looking again at Figure 23, you will see that next to the rough outer bark, there is an inner fibrous bark (*b*), also dead, but inside this is a thin layer of soft bark, too thin to show well in this cut. Just at the boundary line between the bark and the wood is a very thin compact layer (*c*), called the *cambium* (kăm′bĭ-ŭm). Just inside the cambium is the layer of soft sappy new wood (*d*). When you peel the bark off a young sapling, the split occurs at the cambium. The soft new wood is left on the sapling, the watery cambium is split, and the soft inner bark is left inside the hard bark. The soft inner bark, the cambium, and the ring of soft new wood are the three important layers concerned in growth and are the ones we shall study. The raw sap coming up from the roots to the leaves usually and mainly passes up tubes in the new wood, and the prepared food passes down tubes in the soft new bark. This being true, what would be the result if you cut through the bark of a tree down to the cambium all the way round, but did not cut into the new wood? What different result would follow if you cut on through the new wood all around?

34. **How the Crude Food Material Passes Up the Stem and How the Prepared Food Passes Down.**—You remember that the liquid food material passes from the soil into the root hair cells by osmosis, and then passes on in by osmosis

through other cells till it reaches some tiny tubes which conduct the liquid up through the layer of new wood from the root to the leaf. The exact make-up of these tubes is too complicated to go into here. We only need to know that they are made of a special type of elongated cells which by overlapping and fitting end to end afford an easy line of passage through the new wood for the up-going sap.

FIG. 24. The cross-section of a young stem. *e* represents the outer layer of bark; *b* the layer of tough fibres in the bark; *c* the cambium. Seven fibro-vascular bundles are shown lying across the cambium, with the phloem at *a* and xylem at *w*.—*After Bergen and Caldwell.*

In a similar way, there are special elongated cells in the soft inner bark which make up a series of tubes through which the prepared food, or *elaborated* (ē-lăb′ō-rā-ted) sap as it is called, comes back from the leaves and is distributed over the plant. These tubes are not evenly distributed through the new wood and bark, but occur in groups or bundles that are called *fibro-vascular* (fī-brō-văs′kū-lar) bundles. These vascular bundles show plainest in a young stem. Figure 24 shows how these look in the year-old stem of the *Dutchman's Pipe* cut crosswise. The drawing is not complete, and is exaggerated in some respects to make the matter clearer. You see the young bark (*e*) with the tough layer of fibres in it (*b*), and, inside this, the thin cambium layer (*c*). The seven fibro-vascular bundles are seen lying, each one with part of its tubes just outside the cambium and part just inside (*a* to *w*). The tubular part of the fibro-vascular bundle that is outside the cambium in the soft inner bark, and through which the prepared food is con-

ducted, is called the *phloem* (flō'ĕm), and that inside the cambium in the layer of new wood and through which the crude food material passes up is called the *xylem* (zī'lĕm).

35. **Movements of the Sap.**—Unfortunately, the circulation of the sap is not so simple as this account makes it, nor are all the vascular bundles situated exactly as these are shown, but this gives a rough, general idea of the usual, main flow of sap. It differs in different types of plants. In addition to the flow up the xylem and down the phloem, there is some passage constantly going on from cell to cell in all directions by osmosis, and at times some prepared food gets into the xylem, and likewise some raw food material gets into the phloem. For instance, in early spring reserve prepared food rushes up in the xylem to start new leaves, and the sap also regularly passes in and out from centre to outside of the stem through passages in the *medullary* (mĕd'ŭl-lȧ-rȳ) rays that are shown in Figure 23. Again, food has at times to pass up the phloem as well as down. All this you will learn about later. Now we need to keep in mind especially that the main general flow of raw food materials is up to the leaves through the tubes of the fibro-vascular bundles in the new wood, and the main general flow of prepared food is from the leaves back down the phloem in the inner soft bark.

36. **What Forces the Sap Up the Stem.**—The next question is, What forces the sap up the stem along these tiny tubes in the fibro-vascular bundles? Where these tubes have joints in them at the junction of two cells, the fluid passes by the same process of osmosis by which it passed into the root hair. In addition to this, three other forces

are working. First, the outer cells of the root become filled with fluid by osmosis. Their membranes are stretched and they press in on the cells inside them and tend by this *root pressure,* as it is called, to force the fluid out of the roots and up the tubes. Second, the water is being evaporated out of the leaf constantly at the top of the tubes, and this produces a sort of suction which helps to draw the water up the tubes. Third, these tubes are exceedingly fine, so fine that they are called *capillary* (kăp′ĭl-lā̇-rӯ) *tubes.* This is from the Latin word *capillus,* which means a hair. In all such fine tubes there is a force called *capillary attraction,* which tends to force liquid to climb up higher and higher on the sides of these tubes. Figure 25 shows you how you may see this force working in a glass tube. It is this same capillary attraction which causes the oil to rise in the fine tubes produced in a lamp-wick by the closely twisted cotton fibres. You will see later that this force is very important for you to keep in mind, for capillary attraction not only helps to circulate the sap in the plant, but helps also to circulate the water in the soil. By understanding this law, you can learn to keep the water in the soil and save your crops from drought.

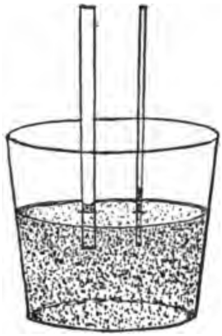

FIG. 25. The working of capillary attraction in tubes of different diameters.

We have obtained a general idea of how the plant gets its food and passes it round to make growth possible. Now let us see just how the well-fed plant goes about increasing its size and adding new stem, branches, and leaves.

37. **How the Stem Increases Its Size.**—You have learned that the plant is made up of a mass of little cells of various shapes and sizes. All plants and all animals are made up of such cells. Some of these cells are so small that many thousand laid end to end would not extend an inch. Figure 26 shows you how some single cells look under a powerful microscope. The growth of a plant (or animal) is brought about by the cells of the plant dividing and each thus forming two new cells and then each cell growing large, dividing again, and so on. Not all cells in a plant are doing this, but the cells in the cambium layer surrounding the woody part of the stem and the cells in the growing point on the end of the stem, which might be thought of as the cambium on the end, are, during the growing season, rapidly dividing. These new cells formed by division then develop, and thus increase the length and thickness of the stem. It is then, in this cambium layer, which has such a rich food supply, that the cells divide and produce the new cells which increase the thickness of the tree. On the inside new wood cells are formed next to the wood cells already there, and on the outside new bark cells

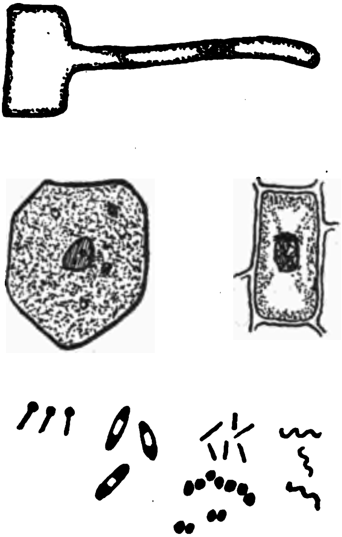

FIG. 26. Various types of familiar single cells, the three above being different types of cells met with in any ordinary plant, while those below are common types of bacterial cells.

next to the bark already there. These cells tend slightly by elongation to lengthen the stem also, but the main lengthening comes from the addition of new cells by divi-

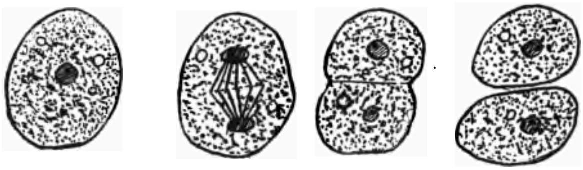

FIG. 27. This shows in a very condensed form how the single cell divides. This division of cells followed by an increase in size of the young cell is the process by which all plants and animals grow.

sion at the growing point on the end, and by elongation of cells just back of the growing point.

38. **Outer Bark and Inner Cells.**—As the new cells are added to bark and wood, and the stem thus enlarged, the old outer bark is burst by the pressure. The new bark will later be burst by the addition of still newer cells, and thus the rough dead outer bark with its deep cracks, which we see on old trees, is gradually formed. A layer of large new cells is developed during the rapid-growing season, and one of small cells during the slow-growing season. This makes part of the wood more dense than the other part, and in this way are

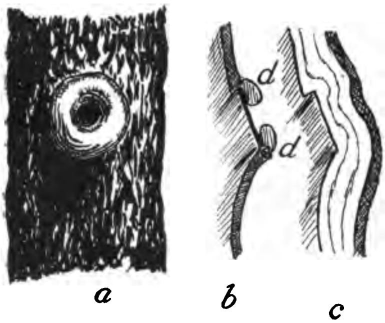

FIG. 28. This shows the healing tissue that the plant is throwing out to cover the wound made by sawing off a small limb. At *b* is represented a longitudinal section, showing the masses of healing tissue (*d*) thrown out by the cambium. At *c* the same plant is shown with the bark perfectly healed and the wound covered completely by new wood and bark.

formed the rings which we see when a tree is cut crosswise. These rings each represent a season of active growth, and, as this usually happens only once a year, they are called *annular* (ăn′nů-lăr) rings, from the Latin word *annus*, which means a year. By counting these rings it is usually possible to tell how old the tree was when cut down. In plants that have no cambium layer, of which we speak later, there would, of course, be found no annular rings.

Fig. 29. The mass of adventitious buds thrown out by a hickory that has been cut off with the purpose of later budding these young sprouts with fine varieties of pecans. A large number of the new branches here have been cut off.

39. **How the Plant Heals Wounds.**—This same cambium layer which forms the new cells for regular growth has the power of doing two other things that are of the greatest importance in the life of the plant. First, when a plant is

wounded the cambium layer produces a healing tissue which soon fills up and heals over the wound with new growth unless the wound is very large. Even then the plant may for years steadily fill in the wounded places by a constant building in of new tissue. This is a very important matter that you will learn more about when you study pruning, budding, and grafting. All budding and grafting are made possible by this power of the cambium layer to make healing tissue and fill up cuts and unite two separated surfaces.

40. **How the Plant Saves its Life.**—The other thing that the cambium layer does, which often saves the life of a plant, is to form new buds. At times a tree or other plant gets broken, or cut off back to a single stem, below which there are no branches or buds. In this case, and at times in less serious cases, new buds are formed in the cambium layer. These buds force themselves out through the bark and thus give the plant a new set of lateral branches on which are again developed the leaves, which the plant must have to gather and digest its food. These new buds formed in an emergency in the cambium layer are called *adventitious* (ăd-vĕn-tĭsh′ŭs) buds. The clusters of sprouts that grow out on a sawed-off tree trunk are partly from adventitious buds and partly from ordinary buds that were before dormant.

41. **Plants That Have No Cambium Layer.**—In a great many of our farm plants there is no definite area of growth or cambium layer, nor does the sap circulate through certain layers, as with the kinds of plants we have studied. The raw food material passes up through vascular bundles that are irregularly distributed throughout the stem, and the food passes back down through different tubes in the same bundles. If you will break a corn-stalk and pull it

apart, you will see these vascular bundles appear as long, tough fibres, pulling out of the pith. In this class of plants are all the grasses, including corn and small grain, which are merely grasses grown primarily for their seed. It is an interesting fact that all these plants without the definite cambium layer have only one cotyledon. Plants with one cotyledon, such as corn and cane, that do not have the special cambium layer, cannot heal cuts in themselves in the same way that plants do which have the cambium layer, nor can they develop new adventitious buds and save themselves if they are broken or cut off below the terminal bud. For the same reason such plants cannot be grafted or budded.

QUESTIONS, PROBLEMS, AND EXERCISES

7. Name some seeds having down on them; some that have wings on them. What purpose do down and wings serve the seeds?
8. Name some seeds having hooks or spines on them. What purpose do hooks or spines serve the seeds?
9. Germinate beans and corn in a germinator, cut them open and point out the seed-case, the reserve food, and the embryo in each. What is the difference in the way the reserve food is stored in these two?
10. Find out how long each of the following seeds will remain dormant without losing its vitality: cotton, corn, wheat, oats, alfalfa, peas, pea-nuts. (See the Appendix.)
11. If the tiny soft root hairs take in all the food materials for the plant from the soil, what happens to the plant when it is torn out of the soil and replanted in another place? In what ways does the plant show the effects of this? When the transplanted plant gets plump again and begins to grow, what do you know must have taken place down on the roots?
12. If the root hairs which take in the water and food materials grow mainly at the tips of the roots and on the new roots, where should you put water or manure for a large tree—near the trunk of the tree or farther out? Why so?

13. Which is the better in transplanting, to pull the plant and roots out of the ground, or to take up the roots together with the soil surrounding them and put both the soil and roots into the new place? Why is it best to do as you say?
14. Take a pan of water and put it on the fire and watch it closely. What makes the little bubbles that you see forming in the water and coming to the top before the water gets hot enough to boil? Where was this air before the water was heated?
15. Take a glass or jar of water and gently put into it some lumps of soil. As the water goes into the pores of the lumps of soil and fills them, what happens that proves the soil has air in it?
16. Let us see in which direction the liquid always passes in osmosis. Could it pass out of the root hair into the soil instead of from the soil into the root hair? Take one ounce of saltpetre and dissolve it in a pint of water. This solution is stronger than the sap in a potato. Call this solution one. Take one-eighth of an ounce of saltpetre and dissolve it in a gallon of water. Call this solution two. This solution is weaker than the sap in a potato. Now cut some slices of Irish potato, about one-eighth inch thick, and put some of these in solution one and some in solution two. Osmosis can go on through the cell walls of a potato just as it does through the membrane of a root hair. Look at these potato chips after a while and see if both lots are still plump, or if one is plump and full of water and the other is limp, and some of the water has passed out of it into the solution. Did the juice pass out to the weaker or to the stronger solution?
17. When we pour strong salt water around a plant and it wilts, what has happened? How could you revive it? Try it and see if it will revive.
18 Sprout a bean or grain of corn between blotting-paper or cloth and mark the root lightly with water-proof ink at intervals of one-eighth of an inch. Replace it in the germinator and watch the growth of the root to see what part of the root grows most. Then mark in the same way the stem of a young bean that has just sprouted out of the soil and see if the stem grows in the same manner as the root grows.
19. Fill a jar with good, moist, loose soil and, as you fill it, plant against the side of the jar, so that they can be seen from the outside, five grains of corn, one at one inch from the top, one at two, one

at three, one at four, and one at five inches. Keep the soil moist and watch the grains from day to day, making notes of the process of germination as you see the grains through the glass. Through how many inches of soil can the corn-plant grow when depending upon the reserve food alone?

20. Plant a dozen each of radish, bean, and other seeds in moist soil; cover with soil and press down the soil on the seeds. Plant the same number of seeds at the same time in the same soil alongside these seeds, only cover these loosely with soil. Note which seeds come up first, those packed or those not packed. Why do these come up sooner than the others? (Remember what the seed must get before it can germinate.)

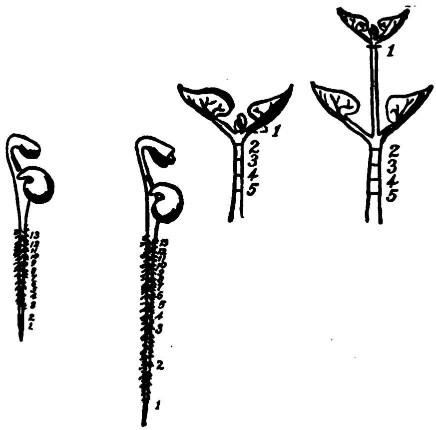

FIG. 30. At the left, in each case, the root and stem marked so as to study how each grows. On the right, the separation of the figures shows the result of growth.

21. Remove a half-grown oat-plant and a wheat-plant from the earth with a shovel, taking up with each a large amount of the soil still in position. Then soak this soil in water and wash it away by pouring over it gently a stream of water. When the roots and root hairs are clean, examine them carefully and see what they are like. Note if there are any differences in the roots of the wheat and the oat.

22. Germinate a bean-seed in the earth and keep a daily record telling when it was planted, the condition of soil and temperature, when it appeared above ground, and what it did each day for ten days. Make drawings every three days.

23. Plant six bean-seeds. When they come up clip both cotyledons off two plants, one cotyledon off two, and leave two untouched. Note the results.

24. Draw a cross-section of a stem, showing where each part that we have studied is situated.
25. Plant three bean-seeds in good soil in each of three small cans or pots. As soon as they germinate, put one in a dark closet or box, one in the room near a window, and one out in the open sunlight. From day to day make a note of the results. Can you tell what makes each plant behave as it does?
26. Explain why it is that when an old field grows up thickly with trees the weeds and grasses that were before in the field die out.
27. Place a glass jar over a plant that is growing in a can or pot, and after twenty-four hours note the drops of water deposited on the inside of the jar. Where does this water come from?
28. Remove the jar from the plant mentioned in No. 27, and water the plant well. Then cover the top of the can or pot with card-board cut to fit closely, or with several folds of cloth, so as to largely prevent the water from evaporating from the surface of the soil. Now weigh the plant, pot and all. Weigh it again next day. Why does it weigh less now? Find out the amount of water lost when the plant sits for ten hours in the sun, and then the amount lost during ten hours in darkness. Why is less lost during darkness?
29. Plants often wilt in sunshine and look plump again the next morning. What effect has this wilting on transpiration? Why?
30. If there are forty-eight full-grown apple-trees on an acre of land, how many gallons of water will be transpired by them in a season? It takes eight pounds to make a gallon.
31. Weigh six good-sized corn-stalks. Then hang these in the air till thoroughly dry and weigh again. What per cent of the corn-plant was water?
32. Where do trees get the food with which to put out new leaves each spring?
33. If a tree stored all its reserve food in an extra large crop of seed this year, what would it have to start growing with next year before it got its leaves? Did you ever know of a tree killing itself in this way?
34. Why do young sprouts come out from the roots of certain trees when they are cut down?
35. How does girdling trees the year before cutting them down prevent the roots sending up sprouts afterward?

36. How do potatoes manage to sprout and grow on the floor without being planted?
37. Why are these sprouts pale yellowish instead of green when the potato sprouts in the dark cellar or closet?
38. Partially burn a match and examine the black charcoal left. Of what is this composed? When the carbon is completely burned and only ashes are left, where has the carbon gone?
39. Burn sugar, starch, and meat, and see if you can see any sign of carbon in them.
40. Name some farm and garden plants that store starch, some that store sugar, some that store oil.
41. To show that the root hairs secrete an acid, take a piece of polished marble, such as a broken bureau top, put wet sawdust on this and plant a seed in it. Keep it moist till the seed germinates and the plant develops several leaves. Then turn the sawdust off the marble and note the fine lines made on the surface of the marble where the root has been against it. This is due to the acid from the root hair dissolving a small quantity of the marble.
42. Animals, including man, take oxygen out of the air when breathing, and put into the air carbon dioxide. The plants take carbon out of the air and put into it oxygen. What would finally happen to man and all animals if the plants did not do this?
43. Girdle a young sapling, cutting completely around the tree down to the cambium layer, but not into the new wood. Watch this tree carefully till the end of the growing season and note what results. Watch it also the following year. Explain the reason for each result.
44. Cut a young sapling in the same way, only cut down through the layer of new wood all around. Note the results and explain them.
45. Cut off a short section of the stem of some young plant, such as the bean, with leaves growing on it. Stick the lower end of this stem in red ink and notice how the fluid passes up the vascular bundles in the stem and on into the ribs and veins of the leaves. Try this also with a monocotyledonous plant, such as corn, and compare the results.

The references for further reading on plant growth are given, together with those on reproduction, at the end of Chapter III.

CHAPTER III

HOW PLANTS ARE REPRODUCED

42. **Three Ways of Reproducing a New Plant.**—We have seen how the plant takes food material, manufactures its food, and grows as a single plant. Let us now see how it produces a new plant. This is done in three ways: by seed, by spores, or by division. Some plants reproduce themselves in more ways than one. We shall not consider spores at this time, but shall study reproduction by seed and by division.

43. **The Parts of a Flower.**—In addition to having buds which open and develop into leaves, most plants have other buds which open and develop into flowers. It is in these flowers that seeds are formed in a most interesting way. Figure 31 shows a peach flower split in two. You will notice on the outside the small half leaf and half scale-like *sepals* (sē′pa̤l). These were greenish in color, covered the flower, and protected it before it opened. All these sepals taken together are called the *calyx* (kā′lĭks). Next inside the calyx are the large *petals* (pĕt′a̤l), which make the pretty white or pink showy part of the flower. All of these petals taken together are called the *corolla* (kŏ-rŏl′la). While these two parts of the flower, especially the corolla, are the ones usually noticed, they are not the important parts. Many kinds of flowers fail to have one of them and some fail to have both. The calyx serves merely as a protection, and the corolla

serves partly as a protection and partly to attract insects, which are needed to help some flowers make seed, as we shall see later. Inside of the corolla you will notice the *stamens* (stā′mĕnz) and the *pistil* (pĭs′tĭl). It is through these that the plant produces a seed.

44. **How the Seed is Made.**—If you should cut open one of these pistils you would find in the base of it a little thing that may become a seed. This is called an *ovule* (ō′vûl). This ovule, however, can never become a perfect seed till it is fertilized by a powder, called *pollen* (pŏl′lĕn), thrown out by the stamens. The plant makes this ovule, and at the same time makes also this pollen powder, but it makes one inside the pistil and the other inside the stamens. They must get together before the seed will develop. As soon as the ovule is ready to be fertilized by the pollen, the pistil exudes a sticky substance on its upper end, and the stamens split open and spill out their pollen grains, which fall on the sticky end of the pistil. There these small grains of pollen germinate somewhat as a seed would, and send down through the pistil a tiny thread-like tube, which is too small to be seen with the naked eye. This tube sent down from the pollen grain will, in a short time, reach the ovule, pierce its wall, and allow the contents of pollen tube and ovule to mix

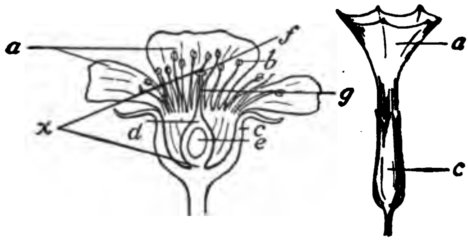

FIG. 31. A peach-blossom cut in two, and beside it a morning-glory. Note the pistil (*x*), made up of the stigma (*f*), the style (*g*), and the ovary (*d*), with its ovule (*e*) within. Note also the anthers (*b*), the petals of the corolla (*a*), and the calyx (*c*).

and thus to fertilize the ovule, so that it can complete the making of the tiny embryo and the storing of the reserve food for the embryo in its seed-case. The falling of the pollen on the stigma is called *pollenation* (pŏl-lĕ-nā′shŭn). If, then, the pollen tube goes down and mixes its contents with the ovule, it is a complete fertilization. The lower end of the pistil in which the seed is formed is called the *ovary* (ō′vȧ-rў). This word comes from the Latin *ovum*, which means an egg. These ovules, as you see, serve a purpose in plants similar to that served by eggs in animals. The top end of the pistil is called the *stigma* (stĭg′mȧ), and the slender supporting stem is called a *style*. Some plants have no style. In these, the stigma is directly on top of the ovary. The stamen likewise has distinct parts. On the top is the little box that holds the pollen, called the *anther* (ăn′thĕr). Below this is the slender supporting stem called the *filament* (fĭl′ȧ-ment). These stamens and pistils in different plants are of all sorts of shapes and sizes, and in varying numbers, just as the calyxes and corollas of different plants vary in many different ways. All that is necessary to produce a seed is that there be a stamen that develops

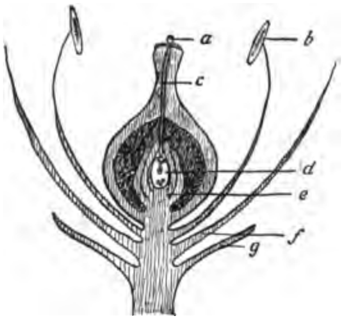

FIG. 32. The process of fertilization of the ovule by the pollen. Note how the pollen-tube extends down into the ovary and comes into contact with the ovule. When more than one seed is to be developed, a tube must be sent down from a pollen grain for each ovule. *a* represents the pollen grain; *b* represents the anther of the stamen from which the pollen falls; *c* represents the pollen-tube; *d* represents the ovule with several cells in it; *e* represents the ovary; *f* represents the corolla; and *g* represents the calyx.

pollen and a pistil that starts the development of one or more ovules, and then that somehow the pollen grain get on the top of the pistil and send its little thread-like tube down and fertilize the ovule. As soon as the pollen has by some means reached the stigma, and the pollen tube has gone deep enough to reach the ovule, the seed in the

FIG. 33. The male flowers (*y*) and female flowers (*x*) of the pecan. Which are borne on the new wood? Where are the others borne?

ovary develops rapidly. If, however, no pollen falls on the stigma, or the tube sent down by the pollen is unable to reach the ovule, no seed is produced. Usually in these cases the ovary dries up, the flower soon dies, and no fruit is produced. This is a frequent cause for failure in the crop of peaches, pecans, and other fruit and nut crops. Some fruits, however, will develop in spite of a failure in fertilization and consequent lack of seed, as, for example, the banana, or seedless grape, or seedless orange.

45. **Male or Female Flowers.**—Usually, both stamens and pistils are made on the same flower, but some plants make

their pistils in one set of flowers and their stamens in another set, as the pecans and walnuts do. Some other kinds of plants, such as the willows, the date-palms, and some of the wild grapes, make flowers with only pistils on one plant and flowers with only stamens on another plant. In both these cases there may be uncertainty about the pollen getting from the *staminate* (stăm′ĭ-nât), or male, flowers over to the pistils of the *pistillate* (pĭs′tĭ-lât), or female, flowers. In such cases the pollen, which is usually a very fine powder, is blown over by the wind, or the insects, which go in and out of the flowers to gather nectar, carry the pollen from the anthers of the male flowers and brush it upon the pistil of the female flowers, and in this way pollenate them. In our field corn, for example, the pollen is usually blown from the tassels, which are masses of male flowers, or stamens, upon the silk of the corn, which is a mass of female flowers, or styles and stigmas, that lead down to the corn ovules below. Sometimes, even when plants have both stamens and pistils on the same flower, these are so situated that it is difficult for the pollen to get from the anther to the stigma. When the anther stands above the stigma the pollen falls easily on it, but when the anther is lower than the stigma, either the flower must hang downward, or the wind must blow the pollen, or some insect must come along and carry it from one to the other on its body. The flowers with white and yellow or other light-colored corollas attract night-working insects especially. The odors of some flowers and the little drops of sweet liquid called nectar in the blossoms of others also attract insects. It was impossible for the Smyrna figs to bear their delicious fruit when cultivated in America until the little insects that feed in their blossoms and carry to

them the pollen from male fig blossoms were brought over here also from Smyrna.

In order then to produce seed, the plant must have food enough to produce the flowers, the germs, and the little stores of reserve food in the seed. We shall see later that certain foods are used in larger proportion by the plant in making seed, while certain other foods are used in larger proportions in making stems and leaves. When the plant has the right food and makes both the ovule in the ovary and the pollen in the anther, the ovule still may not get fertilized, and hence no seed ever develop. In your questions and problems you will have a chance to think out how some of these failures may come about.

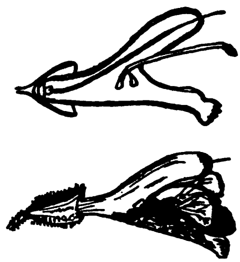

FIG. 34. The manner in which insects help some flowers to get fertilized by brushing pollen on stigmas that would not otherwise be easily reached by the pollen.

46. **Crossing and Improving Plants.**—If the perfect seed is a result of the union of the substance from the pollen and the substance in the ovule, we should naturally expect that, if we put the pollen of a round, flat squash on the stigma of a long-necked squash, the seed coming from this union would have in it a mixture of the characters of the two. This is just what happens. These mixtures of two varieties of the same plant resulting from the pollen of one variety falling on the stigma of the other, and fertilizing the ovule, are called crosses, or *hybrids* (hī′brĭds). Carrying the pollen of one plant to the pistil of another is called *cross-pollenation*.

You can see what splendid opportunity this gives us to improve our varieties of farm plants. One can cross a big-

bolled, heavy-yielding cotton-plant that is not early enough, on an early one that does not have so good a boll, and get a variety that has a mixture of the earliness of one parent and the big bolls and big yield of the other. Or, he can cross a variety of corn that has a fine root system that enables it to

FIG. 35. This shows the effect produced by hybridization of two different types of squash. Note the wide variety of combinations of qualities of the two parents. The long crookneck on the left in the upper row and the flat scallop on the right in the lower are the two parents.
Courtesy of the Macmillan Company. From Warren's Elements of Agriculture.

gather plenty of food material and resist drought, but which makes only fair-sized ears of corn, on another variety that does not have such good root system and drought-resisting qualities, but has large ears. By doing this he may get a hybrid that both resists drought and has big ears. Mr. Burbank in California, Mr. Munson in Texas, and many others have in this way produced fine new varieties. Mr. Munson, for example, has crossed the hardy, wild, sour Texas grapes upon the delicious but delicate Northern and Eastern grapes, and produced hybrids that have the hardy

growth of one parent and the deliciously flavored grapes of the other. There are hundreds more of hybrids that need to be worked out now to give us plants better suited to our Western climate. A trouble with hybrids is that seeds from them may not come true afterward; that is, the seed of a fine hybrid melon may produce a melon that is not like the parent, but like some one of the grandparents, just as a child may not be like either his father or mother, but resemble one of

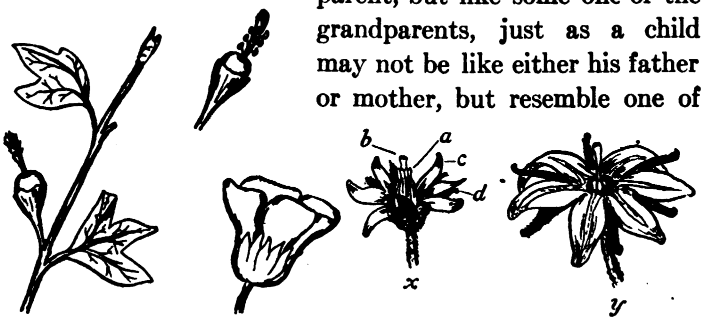

FIG. 36. On the left is a cotton bloom with corolla and stamens cut away ready for cross fertilization and the flower ready to be covered with a bag. On the right is a tomato bloom. x shows the plant before the unripe stamens have been cut away. y shows the flower ready to bag with stamens removed.

the great-grandparents. This failure to come true to the parent is called *variation*. When the variation is due to the cropping out of some quality that belonged to one of the ancestors back of the immediate parents, it is called *reversion* (rê-vĕr′shŭn). This can sometimes be bred out of a hybrid and it can be often made to come true, but the way of doing it will have to be learned later.

47. **How to Cross Plants.**—Let us now learn how to cross two plants. Select two plants belonging to the same species, the flowers of which ripen at the same time. Just before the corolla of the flower has opened, and before the anthers

have opened and let any of the pollen spill, either open up or cut away carefully the corolla, so that you can get at the stamens. Carefully cut away with small scissors or very sharp knife the anthers, making sure that no pollen is left in the blossom. Cover this flower immediately with a small, thin paper bag, and tie it so that no pollen can come to it, either from the wind or an insect. Then examine this flower daily until you find it has ripened enough for the pistil to exude the sticky matter on its stigma. Now take the pollen from a flower of the variety that you wish to cross on it, and gently dust this pollen on the stigma, and immediately cover it again with the bag. Then label this flower and make a record of what you have done. Leave it covered for several days until the ovule or ovules are fertilized and the fruit or seeds begin to form. Since crosses often fail, it is advisable to make several, and to make them on different days, so as to make more sure that you get one or more to live. The larger the number of crossed seeds you prepare, the greater the probability is that one of the plants coming from these seeds will contain a desirable combination of the various qualities that were in the two parent plants.* These

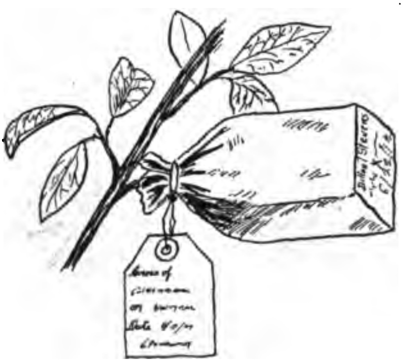

Fig. 37. The crossed stigma protected by a paper bag and labelled.

* The plants resulting from crosses do not in the first generation show mixtures of single characters, as, for example, of color; but they

seeds should be planted well separated from any patch of related plants and carefully watched. If a specially favorable cross is secured, the flowers of this should be protected from the pollen of neighboring plants to increase the chance of its seed reproducing the same fine plant unmixed. By

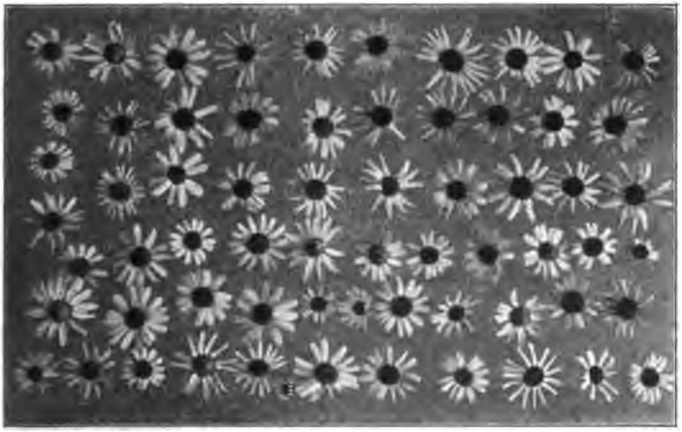

FIG. 38. This illustrates the wide range of variation shown in plants from the seed of the daisy.
Courtesy of the Macmillan Company. From Warren's Elements of Agriculture.

continually selecting and protecting the plants that come true each year, and planting only their seeds, you may soon have seeds that will breed true practically all the time. When you take an advanced course in plant breeding, you will learn a shorter and surer way to make your hybrid come true to seed, but it is too complicated for you to learn now.

show new combinations of characteristics of one parent with other characteristics of the other parent. For example, the first generation may show the shape of one parent combined with the color or flavor of the other. The production of blends of two differing single characteristics, such as a mulatto skin from the mixture of white and black, is rare and not well understood.

In making crosses, the best results have usually come from crossing plants that do not differ very widely, and both of which represent desirable types. In this way many good varieties have been produced.

48. **Variation in Plants.**—One peculiarity about the reproduction of plants by seed is so important that we must study it carefully, for it is the greatest means we have of improving our farm plants. This fact is that even when the seeds of a plant have been fertilized by pollen from the same plant, the seeds will not all produce plants exactly like the parent plant. Some will produce plants that are just the same as the parent, some will be better, and some not so good. The next generation will be different from the parent in many ways. We have already learned that this failure of the offspring to reproduce the parent exactly is called variation, and have seen that the variation may be due to the cropping out of a characteristic of one of the ancestors of the parent plant. There are other causes of variation, but this matter is too complicated to discuss in your first course. In a row of cotton or any other plants, even when the whole row is planted from the seed of one plant, you will notice various types of plants. These differences are due partly to variation. If now you take the seeds from the best stalk in the row, while they too will vary somewhat, and may be partly cross-pollenized from some poor stalk near by, they will tend to reproduce this specially fine stalk and even a few better ones. By constantly repeating this selection, and always taking the best specimens for your seed, you will constantly get a better and better variety.

49. **Results of Selection.**—It is by this process of selection of favorable variations and breeding and multiplying them that practically all of our finest varieties of farm and garden

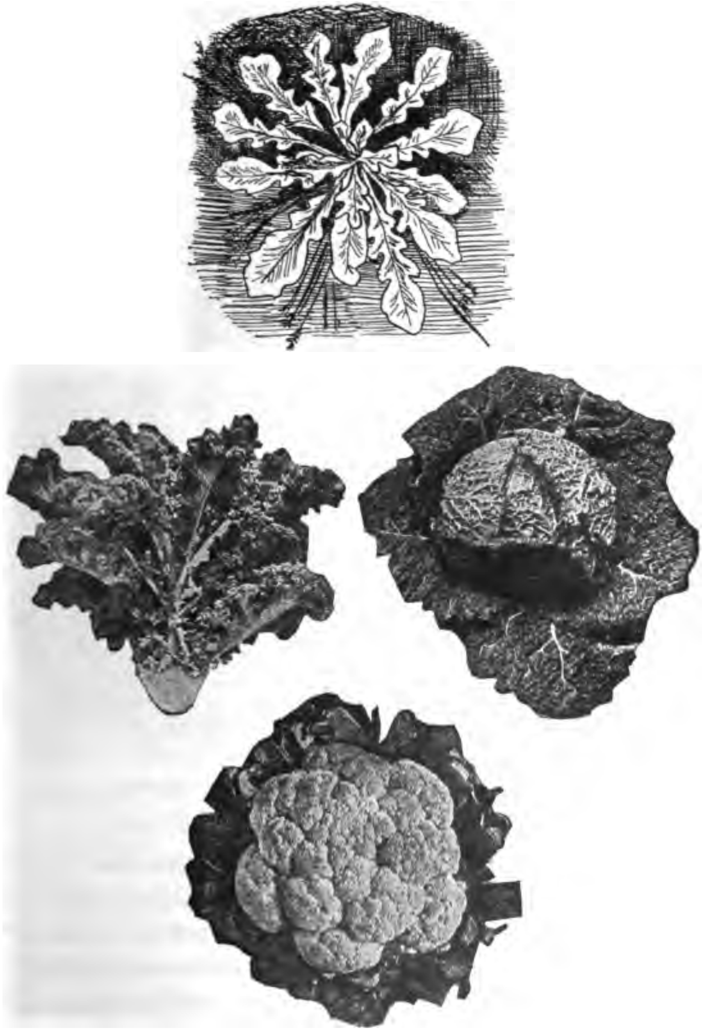

Fig. 39. **Above is the original plant from which by variation, selection, and cultivation have been produced the kale, the cabbage, and the cauliflower which are illustrated below.**

Adapted from Bailey's Encyclopedia of Horticulture.

plants have been produced. As each different soil and climate will best suit a somewhat different variety, there remains still a great work to be done by each intelligent farmer in watching for favorable variations in the crops on

Fig. 40. Reid's yellow dent corn, showing the results of fifty years of selection.

his land, and then protecting these, saving the seeds separately, planting them in a separate place, and, by repeated selection, breeding up the variety best suited to his particular locality. This is a particularly interesting and valuable work for our boys and girls to do. By careful selection, the fine Boone County White, the Reid's Yellow Dent, and the gourd seed corn were bred from variations of ordinary corn. All the kinds of roses we have are but variations of the

simple wild rose that have been selected and carefully bred. All of our varieties of cotton are the results of variations being carefully selected and properly bred. In Wisconsin they have selected and bred a variety of oats that increased the State's yield fifteen million bushels a year. By careful selection it would be possible in a few years to secure varieties of cotton suited to different sections that would add a million bales a year to the crop of Texas, without increasing the amount of land cultivated a single acre. The same is true to a greater or less extent of every State and with every farm crop.

50. **Plants May Reproduce by Division.**—A plant may also reproduce itself by means of some branch or root or leaf of the plant touching the ground, and sending out roots of its own, and developing a top of its own, so that it can draw its food directly from the earth and air, and not be dependent longer upon the old roots from which it originally sprang. The new plant then may be separated entirely from the parent plant. This is called reproduction by *division.* Some plants, such as the potato and the banana, produce so few seeds that it is easier to reproduce them by division. Others, such as the peach and the apple, are so sure not to come true to seed that it is only by division that we can reproduce them with any certainty of what we shall get. So many of our farm, orchard, and vegetable crops are of this kind that it is very important that we learn the chief methods of reproducing plants by division.

Plants make new ones by dividing themselves in three ways, and they are divided by man in four ways. These seven methods of reproduction by division are as follows:

1. *Creeping Stems.* Many plants develop horizontal stems called *stolons* (stō′lŏns), which throw out roots and send up

Fig. 41. See how the blue grass reproduces itself by stolons.

a *culm*, or new shoot, at certain points along the stem, called *nodes*. These stolons may be above ground or below. When below ground thay are called *root stocks*. You see examples of these stolons above ground in the blackberry, dewberry, and most perennial vines. In such plants as Johnson grass and Bermuda grass you see the underground stolons or root stocks.

2. *Enlarged Stems*. At times a great mass of reserve food is stored in a stem, and one or more new germs, or buds which will develop a new plant, are formed in this enlarged stem, or *tuber*, as it is called. The Irish potato is one of these enlarged stems or tubers.

3. *Enlarged Root*. The mass of reserve food and the new germ or germs may be stored in an enlarged root, instead of an enlarged stem. We see such in the common sweet potato.

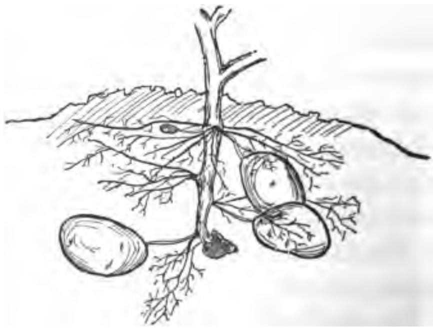

Fig. 42. The Irish potato and the enlarged underground stems or tubers

4. *Layering*. Man often helps out the process of division by

FIG. 43. Note how the tip of the raspberry takes root and grows when layered.

bending stems over and covering them with earth to force them to throw out new roots and new shoots. This is called *layering*. In the raspberry, for example, the tip of the stem is bent to the ground and fastened there, or covered with a little soil, whereupon it throws out roots underneath and sends up a new shoot on top. The next year this new plant is cut loose from the parent plant and will grow. This is called *tip layering*. With the grape, the best plan is to dig a long trench about two inches deep, and, after laying the vine in this, the whole is covered over with soil, leaving only the tip out. This cane will throw out roots and send up stems at each joint, and each of these may be separated and planted elsewhere the next year. With some other plants, such as the gooseberry, the soil is simply piled up twelve to eighteen inches high around the plant as it stands. The new shoots and roots are formed in this soil, and are ready for separation in one or two seasons.

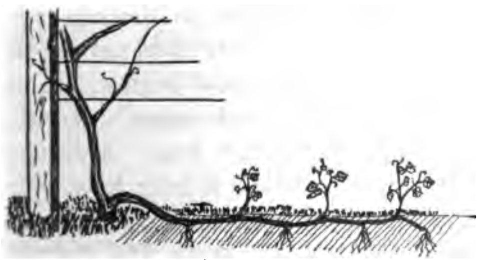

FIG. 44. The method of propagating grapes by layering.

5. *Cuttings.* Most plants that divide naturally and many that do not divide naturally can be artifi-

cially divided by cutting off a piece of the stem, or root, or, in a few cases, a piece of leaf, and placing this under proper conditions. Nearly all plants with a cambium layer can be propagated by cuttings. Some plants are best

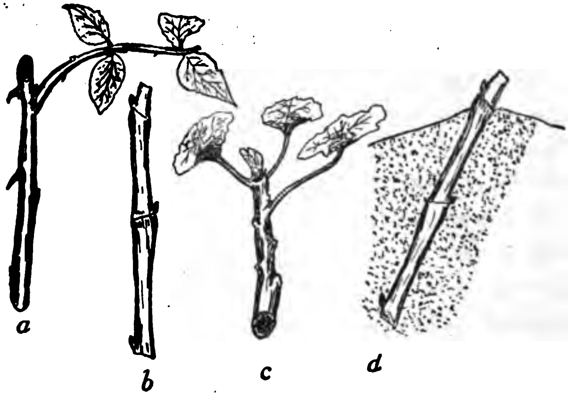

Fig. 45. Cuttings of rose (*a*), grape (*b*), and fig (*c*). At *d* the proper position of the cutting in the soil is shown.

reproduced by one kind of cutting and some by another kind. Some cuttings grow in water, but they usually do best in sand. Likewise, the best season for making cuttings varies. As a general thing, cuttings of fruiting plants are best made when the wood is dormant, in the late fall. This gives the cambium layer time to heal over the wounded surface before the growing season begins. These cuttings should be from wood of the past season's growth, and usually should be six or eight inches long. A cutting may be longer or shorter than this, and it may have only one bud or several buds, but usually cuttings six inches in length, with two or three buds, grow best. The bottom end of the cutting should be made just below a bud, and

the top end from one-half to one inch above a bud. Figure 45 shows how the cutting should be placed in the soil. As soon as the growing season has begun, these cuttings will throw out roots at the lower buried joints, or buds, and the exposed upper bud will start a shoot. Cuttings usually grow better in soil that has very little organic matter in it, as the little bacteria* and *fungi* (fŭn′jī) living on the organic matter often attack the exposed cut surface and cause decay. For this reason cuttings are often rooted in coarse sand. The soil should be moist but not soaking, and should be well drained. The air should be moist and of uniform temperature also, for best results. With cuttings that are hard to root, bottom heat is frequently applied with good results. After cuttings are started they should be carefully cultivated and kept free from weeds and grass, as their roots are near the surface.

Fig. 46. A rooted begonia-leaf cutting.

6 and 7. *Grafting and Budding.* Instead of cutting off a piece of the plant and planting it in the soil to make it grow, we can insert it in the body of another plant and let it grow there. If the part cut off and inserted in the other plant is a bud with a bit of surrounding bark, the operation

* Bacteria are little one-celled plants that have no chlorophyl in them, and with a few important exceptions cannot manufacture carbohydrates out of the raw food materials in soil and air. They must, therefore, live on other plants or animals, either dead or alive, and take their prepared food from them. Fungi differ from bacteria in having many cells and a more complex structure.

is called *budding;* if the inserted piece is a part of a stem, it is called *grafting*. Plants must be closely related, else it is not possible for one to be budded or grafted on the other. Usually, they should belong to the same variety, but sometimes even different species may be budded, as, for example, the peach may be budded upon the plum.

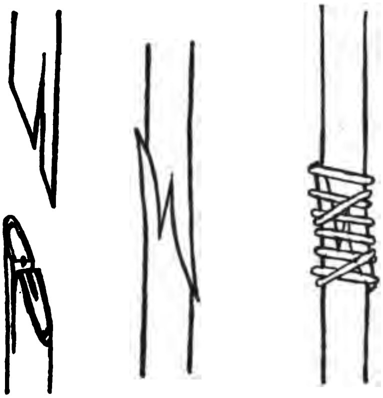

Fig. 47. The method of making the whip, or tongue, graft.

When the transplanted bud or graft lives and grows out of the other plant, all the limbs, leaves, and fruit developing from the bud or graft remain true to the variety from which the bud was taken, in spite of the fact that the raw food material is furnished by the root of the plant in which the bud or graft was planted. This makes it possible to put buds or grafts from fine varieties on trees or vines that bear naturally poor fruit, and thus force them to bear good fruits instead of poor. Most of our orchard trees have long been treated this way, and now the nut trees are beginning to be treated in the same way. Both budding and grafting are easy to learn.

51. **How to Graft.**—Nearly all grafting work is done when the plant is dormant. The plant upon which the piece is grafted is called the *stock,* and the part that is transferred is called the *scion* (sī′ŭn). There are many forms of grafting, but the three most important are *tongue grafting* (or whip

grafting, as it is also called), *cleft grafting,* and *bark grafting.* Tongue grafting is used mostly on young seedling stocks less than an inch in diameter. For plants larger than that, and especially in top working old trees, some form of cleft grafting or bark grafting is generally used.

1. For the *tongue graft* the stock should be about the size of a pencil. The scion should be as near the same size

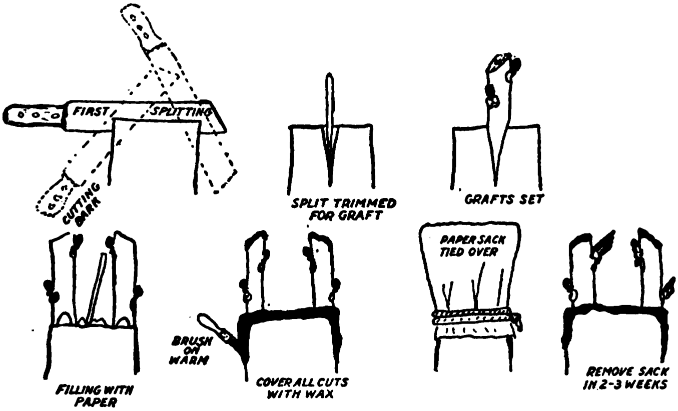

FIG. 48. The process of cleft grafting.

as possible, and should have two or more buds on it. Cut the stock off with a slant, so as to give a cut surface about three times as great as it would have been if cut square across. Then set the knife blade about one-third the distance down from the top of the cut surface and make a vertical incision about one-half inch long. (See Figure 47.) Trim the scion in similar manner, join the two together as shown in Figure 47, wrap with a string, or press stiff clay around to hold the two in place. Knives should always be thoroughly cleaned before cutting into a plant and, as far

Fig. 49. A young cleft graft of pecan growing on a hickory.

as possible, neither the hands nor anything else should be allowed to touch the cut edges. As it is the cambium layer that throws out healing tissue and unites the stock and scion, thus allowing sap to flow from one to the other, it is necessary to use care in fitting the graft so that the cambium of the scion is placed in contact with the cambium of the stock. When this is done, it is easy for healing tissue to unite these, and for the circulation of sap from one to the other to start up soon.

2. The *cleft graft* may be used on small nursery plants also, but it is usually employed on the large plants in putting tops of fine varieties of fruits or nuts on common trees. In cleft grafting, the stock, for best results, should not be over three inches in diameter, while the scion should be the same size as in tongue grafting. In top working an old tree cut back the central limbs with a square cut to stubs four to

six inches long. Smooth the end, then drive down a grafting knife one or two inches as shown in Figure 48. Withdraw the knife and keep the incision open with a sharpened stick. The scion should now be trimmed to a wedge shape as shown, with the inside thinner than the outside to make a perfect fit, and one bud left on the outside near the top. The split edges of the limb should now be cut away in such shape that when the stick is withdrawn the scion will fit tightly in the cut as shown in Figure 48. The scion should now be quickly but gently forced down in the cut, the cambium layer of the scion being carefully placed directly against the cambium of the stock. The stick is then withdrawn. As soon as the scion is in place all cut surfaces should be covered with warm grafting wax, and a string tied around the stump, so as to help hold the grafts in place. A good grafting wax is made by using four parts of rosin, two parts bees-wax, and one of tallow, by weight. These are cut in small pieces, melted together over the fire in a vessel, and poured into water to cool. It is then made into balls, and heated later as wanted.

52. **How to Bud Plants.**—Budding is usually best done during the plant's active growing season. As in grafting, it is necessary that the two plants be closely related, and that the cambium layer of the bud be brought into connection with the cambium layer of the stock. The three most important forms of budding are the *shield bud* (or T bud), the *patch bud*, and the *chip bud*. Nearly all fruit and ornamental trees are propagated by the shield bud, while the chip and patch buds are best with nut trees.

1. *The shield bud* is used mostly on young nursery stock about the size of a pencil, though it is sometimes used also

in top-working old trees. In budding, usually a branch about the size of the stock and containing several leaf buds is cut from the tree you wish to propagate, and the leaves are at once cut off so as to leave about half an inch of the stem of the leaf, or *petiole* (pĕt'ĭ-ōl), as it is named. This branch is called the bud stick and must be kept wrapped in damp cloth or moss. When ready to begin work, first pick

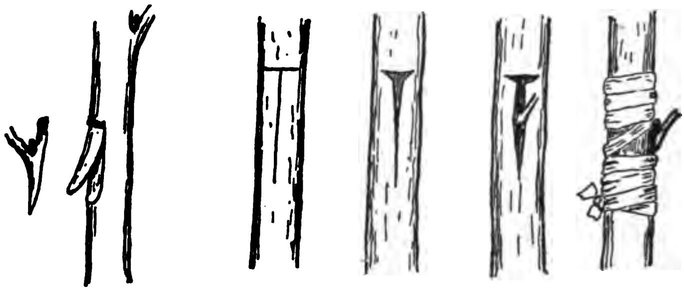

FIG. 50. The steps in the proper method of shield-budding.

out a smooth place on your stock and make a slit through the bark for about one inch in length up and down the stock. Then at the top of this incision make a cross-cut, about one-quarter inch long, giving your incision the shape of a T. In making these incisions be careful to cut through the bark and cambium, but not into the young growing wood. Then cut a bud from your bud stick by placing the blade of a sharp knife about one-quarter of an inch below the bud and cutting upward to a point about the same distance above the bud, but leaving the cut strip still adhering to the bud stick at its upper end. Then withdraw the knife and cut through the bark at the top of the strip that was split off by the first cut. Then, by catching hold of the petiole of the leaf, lift

the bark entirely free from the wood, as shown in Figure 50. Then open the cut on the stock by lifting up the bark in both directions from the cross-cut, and slip the bud from the scion under the bark of the stock, as shown in Figure 50. The bud should then be wrapped as shown, with either raffia, twine, waxed cloth, or similar material, so as to hold the two cambium layers close together and to keep out water, air, and dust. In ten days or two weeks the bud should have united with the stock, and the wrapping should be removed to allow circulation of sap and growth. Part of the stock above the bud and other buds close to the inserted bud should be removed when the bud is inserted, or later when the wrappings are removed. This throws more sap into the bud and forces it out more rapidly. It also makes the stock less likely to be broken by the wind. When the bud has grown about six inches long, all the top of the stock above the bud should be cut off to further force the growth of the bud.

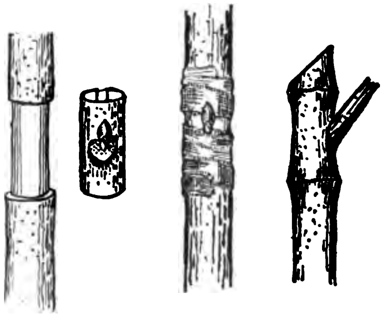

FIG. 51. On the left all the stages of ring-budding, and on the right a successful young ring bud growing.

2. *Ring-budding* is in general the same as shield-budding, except that the cross incision at the top extends entirely around the stock, and another cross incision is made at the lower end of the upright incision, also entirely around the stock. A similar cut is made on the bud stick and the entire ring of bark with the bud at its centre is taken off the bud

stick. The ring of bark is also removed from the stock and the ring of bark and bud from the bud stick are put in its place, as shown in Figure 51. This is then wrapped in the same manner as the shield bud. Here again it is necessary for the two cambium layers to be put in contact with each other, hence it is very necessary to have the piece of bark from the bud stick exactly fit the place prepared for it on the stock. To make this certain, it is best to use a regular ring-budding tool, such as is shown in Figure 52. The stock and bud stick are both cut with the same pair of parallel knives, and hence there must be a perfect fit. When the ring of bark from the bud stick will not reach entirely around the stock, a strip of the bark of the stock is left so as to fill the surface evenly

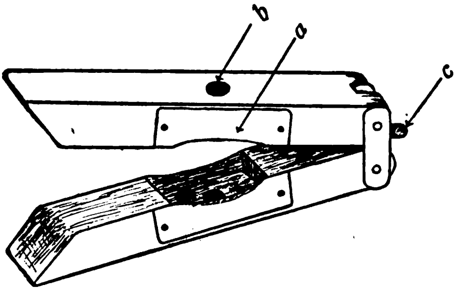

FIG. 52. A shortened and more convenient form of the standard ring-budding tool which was devised by Mr. H. A. Halbert and Dr. Ellis. *a* represents one of the cutting blades; *b* represents the hole for looking at the bud; *c* represents a small blade for slitting and raising the bark.

53. **How to Succeed in Budding and Grafting.**—In all kinds of budding it is especially important that the knives be kept clean, that the cut surfaces and inner bark be not touched by the hands or other things, that the work be done quickly in order to expose the cut surface as little as possible to the air, and that the cambium layers be carefully brought into contact. If these directions are followed, if fresh budding wood and vigorous stock are used, and if the

FIG. 53. The new growth from buds placed in the top of an old pecan-tree which was sawed off for that purpose. *Courtesy of E. E. Risien.*

buds are watched afterward, the wrapping not removed until the buds have started growing, and all sprouts that would rob the bud of its nourishment are kept cut off, you are sure to have success in budding and grafting.

QUESTIONS, PROBLEMS, AND EXERCISES

46. Collect a blossom of each of the following plants, make a drawing, and label each part: peach, plum, strawberry, pea, bean, cotton.
47. Examine a peach, pear, or plum tree before it has budded out in spring, and see if there is more than one kind of bud on it. Draw the branch, showing the buds, and describe each kind. Note later into what each kind develops.
48. Examine the branches of a budding pecan-tree carefully, and find both the male and female flowers. Can you tell now why the pecan crop fails if there is a long rainy spell during blooming season? Can you also see why pecan seeds do not usually come true, but are mixed?
49. Find a male grape-vine and a female grape-vine. Tell how they differ in appearance.
50. Bring in a flower in which the pollen would fall easily on the stigma. Bring in another flower in which it would be difficult for the pollen to get on the stigma, and find out how the pollen is carried in this last case.
51. Select in the field, make notes on, and bring to school especially desirable variations found in one of the following plants: cotton, corn, oats, wheat, cane, milo, Kafir, peas. Plan with your teacher a scheme for breeding and developing this desirable variation. (See the lessons on cotton and corn.)
52. Make and root cuttings of each of the following: rose, fig, grape. Root, by layering, a blackberry and a grape.
53. Select and cross-pollenate two good types of cotton-plant. Save the seeds from those that live, plant them separately, and watch for desirable hybrids. In spring do the same for garden peas, and in summer for field peas and watermelons.
54. In September and October plant apple, peach, and plum seed, to have stock on which later to bud and graft. Plant pecans in January and February.

55. Just before the buds begin to swell in spring, cut off some twigs about as thick as a pencil from the tree bearing the best pecans, and bearing most regularly in your neighborhood. Keep these in a cool place, buried in moist sand, till the buds on the pecan-trees are beginning to swell. Then saw off the tops of two vigorous young pecan-trees, that are about three inches in diameter, about six or seven feet from the ground. Put two cleft grafts in the top of each tree. If either of these grows, keep all natural sprouts cut off about the graft. If any graft fails, let the natural sprouts grow till they are the size of your finger, and then ring bud these as directed in this chapter with buds taken from your best tree.

REFERENCES FOR FURTHER READING

Also consult for fuller list of references on this and all other topics *Encyclopedia of Agriculture* and the *Classified List of Publications of the U. S. Department of Agriculture.*

"Botany: with Agricultural Applications," J. N. Martin.
"Plant Physiology," B. M. Duggar.
"Practical Botany," Bergen and Caldwell.
* "Principles of Plant Culture," E. S. Goff.
"Principles of Breeding," E. Davenport.
"Plant Breeding," L. H. Bailey.
* "Elements of Agriculture," G. F. Warren.
* "Rural School Agriculture," Chas. W. Davis.

Farmers' Bulletins:
No. 157. "The Propagation of Plants."
No. 229. "Production of Good Seed Corn."
No. 253. "The Germination of Seed Corn."

* The books marked with an asterisk (*) present the subject with a minimum of technical terms, hence are especially suitable for the public-school library. Farmers' Bulletins may be secured free from the National Department of Agriculture, Washington, D. C. As new bulletins are issued constantly, no list can long remain complete. Any one who desires information should write to the National Department of Agriculture, the State Department of Agriculture, the State A. and M. College, and the Experiment Station for lists of available bulletins.

No. 266. "Top Working Orchard Trees."
No. 334. "Plant Breeding on the Farm."
No. 376. "How to Grow Young Trees for Forest Planting."
No. 408. "School Exercises in Plant Production."
No. 428. "Testing Farm Seed in the Home and Rural School."
No. 433. "Directions for Making Window Gardens."
No. 471. "Grape Propagation, Pruning and Training."
No. 501. "Cotton Improvement Under Weevil Conditions."
No. 700. "Pecan Culture."
No. 710. "Bridge Grafting."
No. 948. "The Rag Doll Seed Tester."

Experiment Station Bulletins:
No. 54. "Rules and Apparatus for Seed Testing."
No. 186. "Elementary Exercises in Agriculture."

Texas Department of Agriculture Bulletin:
No. 19. "The Pecan and Hickory in Texas."
No. 55. "The Propagation of Pecans."

The A. and M. College of Texas Extension Service Bulletins:
No. B. 55. "Propagating Pecans."
No. B. 21. "Top-Working Pecan Trees."

Texas Experiment Station Circular:
No. 20. "Patch-Budding Large Limbs of Pecan Trees".

CHAPTER IV

THE SOIL

54. **The Study of the Soil.**—We have seen that plants send their roots down into the soil to gather food materials with which to manufacture the foods that nourish them. Let us now see how this soil has been made, of what it is composed, what the plants take out of it, and how we may arrange to keep the soil supplied with the food materials needed by the plant.

55. **The Earth's Surface Once Had No Soil.**—For unknown thousands of years there was no soil at all upon the earth. The surface of the earth was everywhere either rock or water. All soil had its beginning in the breaking and pulverizing of the rock. The main forces that have been and still are working upon the rock and pulverizing it and producing soil are the sun, water, air, plants, and animals.

56. **How the Sun Helps to Make Soil.**—You know that heat expands most things and that when they cool they contract. Perhaps you don't know that the same amount of heat will make some things expand faster than others. The rock crust is heated by the sun by day and cools off again by night. Some parts of the rock expand more than others, because they are made of material that expands more rapidly from heat. The expanding at different rates of the various substances in the rock causes these substances to pull loose from one another. Likewise, those parts of even the same substance

which are more exposed to the sun, heat more quickly and expand more rapidly than do the parts less exposed. Because of this the heated parts pull away from the other parts that are not so heated, just as the outside of a glass bottle when dipped suddenly into boiling water will expand at once, pull away from the cooler part, and break the bottle before the inside gets hot enough to expand and keep up with it. This constant expansion and contraction produced by the heat of the sun has always been cracking and pulling apart the exposed surface of the rock crust just as you have seen it crack a cement sidewalk. This force would, of course, do most work where the heat and cold are extreme and where the changes are sudden.

57. **How Water Helps to Make Soil.**—The water, first falling as rain, has passed for millions of years over these rocks, and has worn them by rubbing, and dissolved them, or otherwise changed them by chemical action. When the water has carbon dioxide in it, as you will soon see that it frequently has, it dissolves the rock much faster. The water further breaks up the rock by getting into the cracks and freezing there and bursting the rock. After the rocks are broken, the water grinds them finer by rolling them against each other, and frequently carries them great distances. You have often seen the mass of well-worn stones of all sizes that are deposited along the beds of our rivers and creeks. However, the greatest amount of material carried by the water is the lighter and more finely powdered soil which is suspended in the water as mud and deposited over the fields in the valleys. All river bottom-lands and other lowlands are deposits brought there by the water. In addition to the wearing and grinding and carrying of rock and soil by the streams of water, there

are, in high cold mountains, rivers of ice and snow that flow along, though extremely slowly, dragging and grinding rock as they go. These rivers of ice are called *glaciers* (glā′shērs). At a very remote date, when the climate of the world was very different from what it is now, there were much larger caps of ice at each pole than there are now, and these huge caps of ice spread out and flowed in the form of many glaciers toward the equator. These immense glaciers broke off great masses of projecting rock and ground them to pieces as they dragged them along. In this way they carried along and crushed great quantities of stone and helped to make a considerable amount of soil in the northern part of our country. As they melted long before Texas was reached, we have no glacial soil in Texas or the Southwest.

58. **How the Air Helps to Make Soil.**—The air wears the surface of the rocks, by blowing piece against piece, just as the water does, only more slowly. It is also constantly changing some of the rock by a chemical combination of a substance in the air with some substance in the rock, just as the oxygen of the air unites with all exposed iron surfaces and forms rust. When a rock is being worn and in other ways changed by water and air, it is said to be *weathering*. Rock that has been changed and broken up by water and air, or by other means, until it is all in fine pieces, is said to be *disintegrated* (dĭs-ĭn′tē̇-grā-tĕd).

59. **How Plants and Animals Help to Make Soil.**—The plants that first began to grow on the earth were of a low order, such as could live in the powdered and ground-up rock. Upon the death of these plants, this vegetable matter was added to the soil. This added not merely that much matter, but the decaying vegetable matter held water and air in the soil bet-

ter than they had been held before, and also gave rise to an acid which helped to dissolve the rock faster. The acid given out by the roots of the plants also helped to dissolve the rock, and the roots growing into cracks soon expanded and split the rocks farther apart. The bodies of the animals that ate the plants likewise went into the soil after their death. These decaying animal bodies had a similar effect to that produced by the plants. In addition to this, the worms and other animals that live or burrow in the soil open it and move enormous quantities of soil from one place or one depth to another.

60. **Of What the Soil is Composed.**—The soil, then, is this finely divided surface of the earth in which plants may grow. Its composition is nothing like so simple as most people suppose. It is by no means mere dead matter. Besides the various sized particles of the ground-up and disintegrated rock, and the decaying or decayed bodies of plants and animals, the soil contains innumerable millions of microscopically small living plants and animals that feed upon the dead and living organic matter in the soil. In the innumerable pores in the solid matter are vast quantities of water, air, carbon-dioxide, and other gases.

61. **How Soils Are Named.**—Soils are named and classified in various ways. The most common way is according to the size of the particles composing the soil. Soil composed of the finest particles is called *clay* soil. This is a misleading name, for clay is often used to refer to a particular kind of fine soil that comes from the disintegration of a certain class of rocks. However, in agricultural books any extremely finely divided soil is called clay. The particles of a purely clay soil are so fine that they cannot be distinguished separately with the eye, nor can they be felt separately when the soil is mashed be-

tween the fingers. Some clay soils have particles less than $\frac{1}{25000}$ of an inch in diameter. Next above the clay in fineness comes the *silt*, which is the fine soil deposited by streams or pools of water. Then come, in order of fineness, very fine sand, fine sand, medium sand, coarse sand, and gravel. These need no explanation. Names are given to soils also in accordance with the amount of vegetable and animal matter in them, and the condition of decay of this matter. If there is a great mass of almost pure vegetable matter, not very much decomposed, it is called *peat*. This soil is found in swamps where rich vegetation has fallen year after year into the water and has been so covered that it has not thoroughly decayed. This decaying mass is often dug up, dried, and used as fuel. Such soil is not used for farm crops. When the vegetable matter is very plentiful but is more decayed, it is called *muck*. This makes a rich, black, loose soil that holds much water and, if properly drained, supports finely a few special crops. A soil that has some clay, and enough sand to make it loose, is called a *loam*. A fine soil that has been deposited by the water is called a *silt*. Practically all soils have more or less vegetable matter mixed with the other particles. Many soils are mixtures and have compound names, such as sandy loam, gravelly loam, clay loam. These are so easily understood that they need no explanation. A sticky clay soil that is hard to plow is called a *heavy* soil, and a loose sandy soil that is easy to work is called a *light* soil. As a matter of fact, a yard of clay soil is lighter than a yard of sand; that is, it weighs less. A soil that warms up quickly is called a *warm* soil. A sandy soil that drains well and is open for the free circulation of air is usually warm, while a sticky, tight, clay soil is usually a *cold* soil. The upper and more porous layer of the soil, which has

the organic matter in it and has been greatly modified by the action of the air and water, is usually spoken of as the soil, while the compact, hard, usually lighter colored layer below, which has little or no organic matter in it, and has been less affected by air and water, is called the *subsoil.*

62. **What Purpose Each Part of the Soil Serves.**—We have seen now that the soil is made up of rock particles and decayed or decaying vegetable and animal matter. It is filled with water and air, and contains billions of microscopic living things. Let us see now what part each plays in the production of our farm crops and how we can use each to the best advantage.

63. **The Rock Particles in the Soil.**—The rock particles make up the bulk of most soils and give 65 to 95 per cent of the weight. These particles, when disintegrated and dissolved in the soil water, furnish the plant the original mineral food materials. They also act as a reservoir for holding the water, air, decaying vegetable matter, and other things. As it is the thin film of water surrounding each little particle of soil that does not flow away at once, and is left for the use of the growing crop, you can see that the finer the soil the more of this valuable soil water it can retain, because there is a greater amount of surface for holding the water in a cubic foot of small particles than in a cubic foot of large particles. The sum of the surface areas of all the particles in any soil measures its water-holding capacity. It has been calculated that the sum of the surface of all the particles in a cubic foot of soil is 37,700 square feet, when each particle has a diameter of only $\frac{1}{1000}$ of an inch. This is about the actual diameter of the particles in a coarse river-bottom silt. Clay is much finer than this. Just as the finely divided soil exposes more sur-

face to hold water, so it exposes more surface to be acted on by the water, air, and other things in the soil. In this way more food material is constantly being disintegrated for the plants that are growing in the soil.

64. **Water in the Soil.**—The most important element in the soil is the water, because it is itself a most important food material, and it is the means of dissolving all the other food materials so that they can be taken in by the root hairs of the plants. After a heavy rain, every pore in the soil is filled with water, but very soon all the free water in the larger pores drains away, leaving a thin film surrounding and adhering to each tiny soil particle. This mass of films of water left is called *capillary* water, because it is held and moved from place to place in the soil by capillary attraction, about which you have already learned. It is this capillary water, filled with dissolved food materials, that is the mainstay of our farm crops. This water moves very slowly in every direction, passing from particles that are wet to particles that are drier. In this way, as the surface particles of the soil are dried by the sun and wind, the water passes up from below to these dry particles by capillary attraction, just as oil passes up a wick as fast as the blaze burns it off at the end. In the same manner, as fast as the root hairs soak up the soil water surrounding them, the soil water moves by capillary attraction from the neighboring moist particles to these dried particles and thus gives a continuous supply to the plant as long as there is any

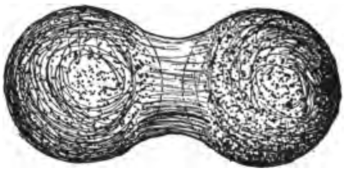

FIG. 54. This shows how the films of capillary water pass from particle to particle of soil, passing always toward the dry particle.

capillary moisture near by, and as long as the pores of the soil are not too large for the water to pass by capillary attraction.

65. **Air in the Soil.**—Most good soil is about half air space. After a rain, or where not properly drained, the water fills this space, pressing out the air. Plants, as you have learned, must have air to live. A few plants can get enough air out of the soil water to live, but most farm plants demand more air than is contained in water, and will as surely drown in water-soaked soil as a man will in a pond, though they drown more slowly. The air in the soil serves several purposes. It contains free nitrogen which is in part changed into a soluble form in the soil, so that the plant can absorb it. You will soon learn that there are in the soil some especially helpful little microscopic *organisms** (ôr′gan-ĭzmz) that are able to take the free nitrogen of the air which the plant cannot use, and work it into a soluble nitrogen compound which the plant can use. Unless there is a plentiful supply of air in the soil these little organisms are not active. Not only is this true but,

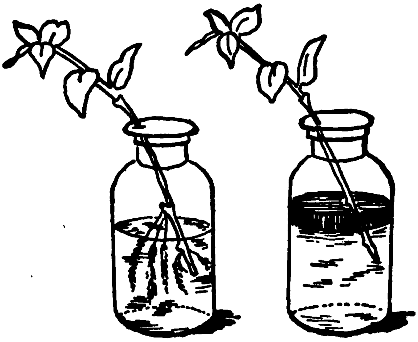

FIG. 55. The water in the bottle on the left is fresh, that in the one on the right has had the air boiled out of it and other air is prevented from entering by the film of oil on top. The cuttings were put into the bottles at the same time. Note the effect of air in the water upon growth.

* *Organism* is a general term which may refer to either a plant or an animal, and *organic matter* is a general term which refers to the matter of the bodies of either plants or animals.

when the soil is full of water, another group of organisms in the soil that tear down soluble nitrogen compounds gets especially active and destroys the soluble nitrogen food materials that are already in the soil. The yellowing of plants when the water stands long on the soil is thought by some to be due to the lack of nitrogen.

66. **Organic Matter in the Soil.**—The decaying organic matter in the soil is called *humus* (hū′mŭs). It is usually the humus which gives the dark color to the soil. While it is possible to grow a plant in pure sand, if all the food materials are added in chemical form, it can be said that for practical field purposes humus is necessary for all successful crop production.

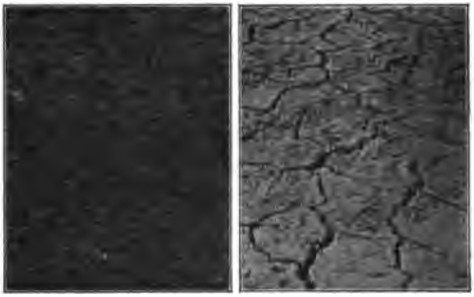

FIG. 56. If humus had been added to the soil on the right and a dust mulch had been maintained on it, it would have held its water as did the soil on the left.

Humus serves many good purposes. As dead bodies contain practically the same substances that they do when living, they give back to the soil a good part of what the plant took from it when growing. In addition to this, humus serves four other good purposes. First, it increases the water-holding capacity of the soil; second, when a soil is too tight, it helps to loosen it up and get air into it, and when it is too loose it helps to fill the large pores and bind the soil together; third, it furnishes food for and encourages growth of helpful bacteria that change the insoluble nitrogen into sol-

uble nitrogen compounds; fourth, while it decomposes, it sets free carbon dioxide, which, when mixed with the water in the soil, helps it to dissolve more food materials for the plant. You see then that the value of humus is far greater than the mere value of the food material contained in the bodies of the dead organisms that compose it.

67. **Living Organisms in the Soil.**—While worms help to make the soil porous and to decompose some of the vegetable matter, the greatest work done by living organisms in the soil is that done by very small plants—moulds, yeasts, and bacteria. The little bacteria are so small that they can be seen only with a strong microscope. It takes about 150,000 of the smallest of them to stretch an inch, and it takes about 25,000 on the average to measure that much. They are one celled plants, and can multiply every few minutes by each dividing into two, just as you saw that the cells in the cambium layer of the tree do. The number of these little plants in the soil is astonishing. A soil poor in bacteria would have over 20,000,000 per ounce, while a rich soil might have many billion in an ounce. Some bacteria are very harmful, destroying the useful nitrogen compounds in the soil, but the vast majority of them are of the greatest use. They cause the decomposition of the humus in the soil. Some tear down especially the carbo-hydrates, some the fats, and some the proteins. The insoluble proteins are broken down and part of the nitrogen is changed to ammonia which is in turn changed to a soluble nitrate which the plants can use. If it were not for the action of these bacteria, all plant and animal life would soon cease. The plant, as you have seen, takes the crude food materials (water, carbon dioxide, nitrogen compounds, etc.) and makes them into sugar, starch, fat,

and proteid foods, which the animals, including man, must have to live on. These foods the animals eat and return at once in large part to the soil as manure. Later on, all of the remainder not returned as manure is returned to the soil in the dead bodies of the animals. In this way the soil gets back everything that was taken from it. But the roots of the plant cannot take in the fats and proteids and other compounds in the manure or in the bodies of the dead animals or even of the dead plants until these are changed. If something did not step in to break up and change these insoluble organic compounds into simple soluble crude food materials again, the soil would soon become a mere mass of corpses and all plants would starve for want of food materials on which to live. Here is where the little bacteria come in. They tear down the dead organic matter and help to prepare the crude food materials for the use of the growing plants again, and thus complete the circle, so that the round of nature can go on and on forever. In addition to tearing down the organic compounds, the action of the bacteria has a valuable indirect result. During the process of decomposition of the humus, acid gases are produced which help with the decomposition of the rock particles. Some of these bacteria also take free insoluble nitrogen out of the air and make from it soluble nitrogen compounds.

68. **How to Improve the Soil.**—We have now seen that the soil is composed of finely divided rock particles, of organic matter in various stages of decay, of living organisms, and a varying quantity of water and air, which fill the pores and take up about half of the space of a good soil. Let us now see how the soil can be treated so as to make it most favorable to the growth of the plants rooted in it. If we will keep in

mind what we have learned about the way plants feed, and the composition of the soil, we can soon reason out what is necessary to do in order to favor the growth of plants.

69. **How to Make the Soil Hold More Water.**—We have seen that plants can take food materials from the soil only in

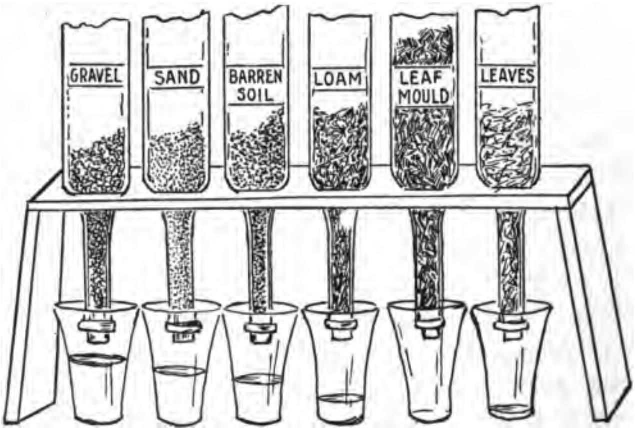

Fig. 57. An inexpensive equipment for testing the water-holding capacity of soils.
Courtesy of the U. S. Department of Agriculture.

liquid form, and hence that, without a supply of water, the plant can get no food material at all from the soil, no matter how much is there. Many of our arid Western lands are rich in food materials, but crops starve to death in them from want of water. Then, the first essential of good farming is to keep plenty of moisture in the soil. We have seen that after a rain the soil has in it not only capillary water, but free water that fills the larger open spaces between the soil particles. The valuable water for the crop, as we have seen, is the capillary water left surrounding the tiny soil particles after the free

water is drained away. In order to increase the amount of this water left in the soil, the first thing to do is to break the soil into as fine particles as possible and thus give more surface for the films of water to stick to. Some fine clay soils can hold as much as forty pounds of capillary water in a hundred pounds of soil, while some very coarse soils hold as little as five pounds per hundred. Breaking the land also makes more large pores, and hence, when a rain falls, less of it runs immediately off. Of this water that is caught in the large pores, a part runs off into springs and streams, a part may go down and be left as a reservoir of free water, or may diffuse itself as capillary water further in the soil. However, land that has been broken and opened up tends to pack together again. One of the best things to prevent this and to help keep such land porous and capable of holding water is a plentiful supply of humus in the soil. Some land has the opposite trouble. It is coarse and open, so that the water drains out too rapidly, there being only the small amount of surface of the large soil particles for the films of moisture to stick to. In such land humus helps to fill the pores, delay the water, and furnish surface to which the films of capillary water can adhere. In order, then, to increase the water-holding capacity of soils, we should break our land deep and thoroughly, and put into it plenty of organic matter such as manure and turned under vegetation.

70. **Capillary Water Moves Toward the Dry Particles.**—As soon as the water is in the soil, it begins to come out. The free water is carried down by the force of gravity, and the capillary water begins to move slowly toward the surface of the soil. As rapidly as the sun and wind evaporate the water that is on the soil particles at the surface and these become

dry, the capillary water on neighboring particles moves up from the wetter particles below to these dry particles. This water is then evaporated and still more water comes up from below by capillary attraction and is in turn evaporated. This continues as long as there is any capillary water in the soil, for capillary water moves constantly, though slowly, toward the dry particles. While the fact that capillary water moves always toward the dry particles and causes the water to be lost from the soil by evaporation, it is the salvation of the plants, for, as we have seen, in the same way, as fast as the root hairs take up the water from the soil particles next to them, the soil water from other particles near by moves by capillary attraction over to these dried particles and thus keeps the root hairs supplied with water. In this way a twenty-five-bushel-per-acre crop of wheat uses on the average about five thousand pounds of water per day, or a million pounds in a season, for each acre. While the plant takes an immense quantity of water from the soil in growing, the loss of water from evaporation of the capillary moisture from the surface of the soil may be much greater. It has been estimated that on a hot, dry, windy day as much as 40,000 pounds of water may be lost by evaporation from the surface of one acre of ground. That is as much water as is used by the

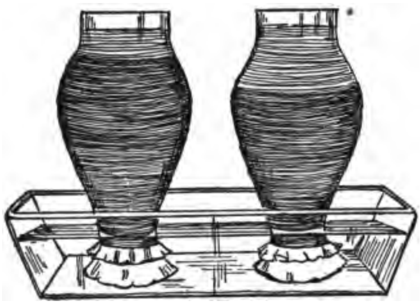

Fig. 58. An inexpensive equipment for testing the capillary rise of water in soils. The chimneys should have fluted tops in order to admit water freely to the soil.
Courtesy of the U. S. Department of Agriculture.

plants in producing from 400 to 500 pounds of green corn or wheat.

71. **How the Dust Mulch Prevents the Loss of Water.**—The important question, then, is, how can this evaporation of capillary water from the surface of the soil be prevented? The only practical way to do this is to prevent this water ever getting to the surface and being exposed to the wind and sun. You have often noticed that when all the soil around was baked dry and hard, there would be moisture in the ground under a pile of old stones or brick-bats. This is because the stones protected the top of the soil from the sun and wind, and the air spaces in between the piled brick and stone were too large for the moisture to pass over them by capillary attraction and come to the top of the pile and be evaporated. You have often seen how the soil is kept moist in the same way when protected by a board lying on it close enough to prevent the air circulating freely over the surface of the soil, yet not close enough to allow water to pass freely by capillary attraction from the soil on through the board. This shows us how we may save or conserve the moisture in our soil. We cannot put boards or rock piles all over our field, but we can by proper shallow cultivation put all over the tops of our fields a layer of an inch or so of loose soil that is so open and

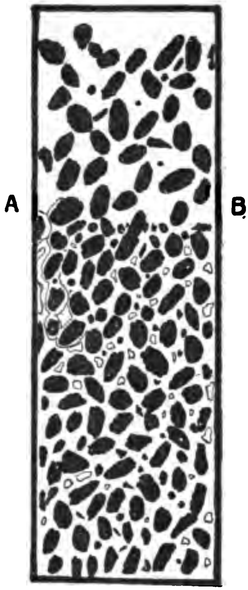

FIG. 59. This shows how the dust mulch prevents the rise of water to the surface of the soil. The capillary water passes freely through the small spaces between the packed particles of soil below the line A B, at which the mulch begins. Above that the larger open spaces prevent the rise of the water by capillary attraction.

porous and has such wide air spaces between it and the soil below that the capillary water cannot pass over these spaces and get up to the surface to be evaporated and lost. While there will be some points of contact at which water can pass upward, these will be so few that the loss will be very small as compared with what it would be without this *dust mulch*, as such a layer of loosened top soil is called.

72. **Dry Farming.**—So successful is this system of conserving moisture, that in some sections where enough water for a crop never falls in one year, the water falling one year has been caught and held in the soil until the next year by breaking and opening up the land before the brief rainy seasons so that it will better catch the rain, and by harrowing it as soon as possible after each rain to make a dust mulch to hold the water. In this way, the water falling during one year is added to that which falls the next year, and thus enough water is secured to grow a good crop every other year, instead of making a failure every year, as was done before this was learned. In most parts of the Southwest there is enough rainfall to produce a crop each year, but the dry air, hot sunshine, and frequent winds make it especially important that every means be used to prevent the moisture in the soil coming to the surface by capillary attraction and being wasted by evaporation. Now that we have learned the principles of water conservation, the matter is in our own hands.

73. **Supplying Water to Crops Artificially.**—In addition to the above methods of keeping a supply of water in the soil, it is often possible to add by artificial means a great deal to the natural supply of water furnished by rainfall. Over a third of the land of the United States is too dry to produce a crop without some artificial means of providing water. The fur-

nishing water artificially to the crop is called *irrigation* (ĭr-rĭ-gā′shŭn). A very large part, though by no means all, of this waste land may be made to yield fine crops by irrigation. Lands in Texas that were before worth only a dollar or two an acre have, since irrigation has been provided, brought two or three hundred dollars per acre. Irrigation has been prac-

Fig. 60. An irrigation canal on the Pecos at Rock Cut.
Courtesy of "Farm and Ranch."

tised for thousands of years. The laborers of Egypt used to carry the water from the River Nile in vessels and pour it on the plants. Later, wheels were so placed that the current of the stream would turn the wheel and by machinery lift to a higher level a part of the water, which would then be led by pipes and ditches to the field. Some of the Indians practised irrigation in our country before the white men came, but the great progress in irrigation has come in very recent years.

Fifty years ago there were less than 100,000 acres irrigated in the United States. Now there are over 10,000,000 acres under irrigation and the rate of increase is rapid.

74. **Not All Sections Can Be Irrigated.**—In a large part of our arid land irrigation is not possible, because there is not a sufficient supply of underground water to be pumped from wells, nor is there enough rainfall to supply surface water for irrigation even if all of it were saved. In other sections there is plenty of water, but it contains substances which would accumulate in the soil if it were used for irrigation and would soon poison the land so that no crops would grow. For example, the water in the upper Brazos is slightly salty, and if used long for irrigation would ruin the land. The water from many of the flowing wells contains so much of salt or soda or of certain sulphur compounds that it cannot be used for irrigation. Before using water for irrigation one should always have it carefully analyzed to see if it has harmful substances in it that would accumulate in the soil and ruin it in a few years. Occasionally, even when the water itself is harmless, it cannot be used for irrigation because of the nature of the land. This is true at times of soils that have underneath them a layer of *alkali* (ăl′kȧ-lī), or other substance injurious to plants. The water when flooded over the field goes down to this poison layer, dissolves some of it, and brings some of this poison up to the surface by capillary attraction. The poison, being in this way brought up where the plants will absorb it, destroys the crops. When unintelligently used, irrigation is as great a danger as it is a blessing when properly used.

75. **Methods of Irrigation.**—The methods of irrigation are many, but are not hard to learn if you will study the bulletins

to which you are referred. There is space here only to give a very general idea of a few methods. At times a small stream or part of a river is led by a canal from its regular channel and carried along until there has been fall enough in the land for the bottom of the canal to be about level with the top of the ground. The water is held in the canal by banks built partly above the level of the ground. From this large canal smaller canals branch off and distribute the water to different fields. Then, each field has running through it a series of smaller ditches coming from the canal. Into these ditches the water from the small canal is turned whenever the crop needs water. Sometimes these ditches are close enough together for the water, by soaking through the banks, gradually to wet all the land. More often the ditches are broken at certain places when water is needed and the water allowed to pour over the field. The field must be nearly level, and the ditches laid off with care. Often the water, when let out of the ditch, is led down the rows in the field. At other times the field is simply flooded all over. In many cases the water is pumped by engines from a stream or lake through pipes to a canal or to the field, and then spread over the field by ditches or by other means. In many places wells are bored and the water pumped or allowed to run into a large tank, from which it is led by pipes or small canals and ditches over the field. In some places, especially on truck farms, a net-work of pipes is raised on poles over the field. These pipes have holes bored in them, so that when the water is turned into them they sprinkle an artificial rain over the crop. In other places the pipes are laid under the ground and the water turned into these so that the supply of water goes directly to the roots of the crop, and less of it is lost by evaporation.

76. **Irrigation in Texas.**—Along the Rio Grande, especially around Brownsville and Laredo, great quantities of formerly almost waste land are now irrigated from the river and producing remarkable crops. In the Toyah Valley and Fort Stockton region, water for irrigation is secured from springs and small streams. Around Barstow the water is taken from

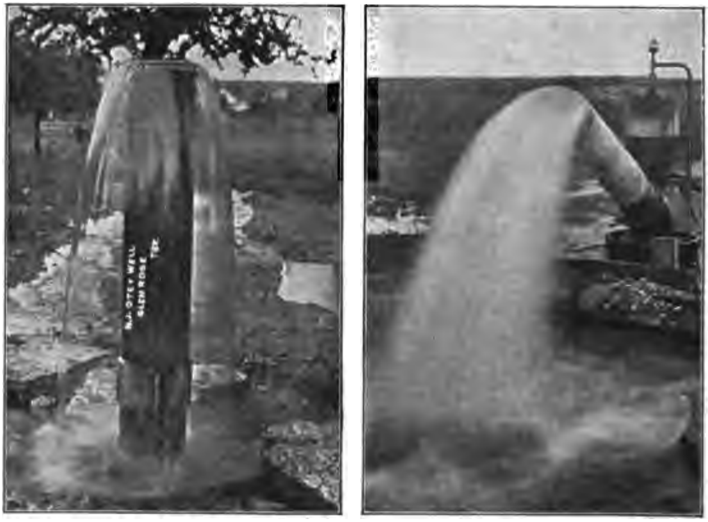

Fig. 61. A flowing well in Glen Rose, Texas, and a pumped well near Midland, Texas.

the Pecos River. Around Beeville and in the section southwest of San Antonio, and lately in many other parts of Texas, large wells are sunk and water pumped into tanks for purposes of irrigation. In Somervell County and in many parts through central Texas flowing wells are used. In fact, every month or so brings an account of some new section in Texas in which it has been found practicable to use irrigation either from wells or surface water.

77. **The Need of Conserving and Using Wasted Water.**—The saving of wasted water and applying it to the fields is one of the most important economic matters before the people of our State. Enough water goes to waste in floods in our State to add millions to our annual production. Each year more and more of this water should be conserved and used. A good way to learn more about irrigation by practical experience on a small scale is to study the bulletins on this subject and then prepare a garden spot near a tank on your place and irrigate a vegetable garden. Every farm in a dry section that has a tank should have at least an irrigated garden.

78. **How to Keep Air in the Soil.**—We have seen that all plants must have air to live, and that in a good soil about one-half of the space is taken up by air. As the soil settles down and is packed by the rains, the pores in it are made smaller and smaller, and the air is slowly squeezed out. The result is that the favorable bacteria in the soil do not flourish, as they too need air; nor is the free nitrogen of the air changed into soluble nitrogen compounds as rapidly. The remedy for this is simple. First of all, before the crop is planted, the soil should be broken deeply and turned again until the particles are well broken apart and plenty of air is mixed with the soil. Then, after each rain, when the patter of the water on the surface has run the top of the soil together and largely closed the pores, this tight crust, which tends to shut off the entrance of air and the circulation of air in the soil, must be broken by cultivation as soon as the land can be worked. The same loose mulch which we saw makes it difficult for the water to come out of the soil also makes it easy for the air to get in.

79. **The Injuries Resulting from Water-Soaked Soil.**—Whenever water enters the soil, this water takes the space that

has been occupied by air and drives out that much air. A completely soaked soil has therefore no space left at all for air, and contains only so much air as is contained in the water. We have seen that only a very few crops can live with so little air. It is therefore necessary to get the surplus water out of the soil in which most crops are growing in order to allow the air to get to the roots. The water-soaked soil also encourages the growth of the injurious bacteria which tear down and destroy the valuable nitrogen compounds already in the soil. Fortunately, in most soils the free water goes down rapidly to a point below that reached by the roots of ordinary farm crops, and rests in the permanent bed of ground water, or it goes down until it strikes a layer that it cannot penetrate, and runs along over this layer until it finds an outlet in some spring or stream farther down the hill. There is, however, a great deal of land which is so close that water penetrates it so slowly that the average farm crop dies for want of air before the free water escapes after long rains, or before the water which runs into this soil from the soil of neighboring higher ground can find its way out. Such soil often has below the top soil a still closer subsoil, which makes the passing down of the water impossible. In all these cases of soils that are soaked with water near enough the surface to shut the air from the roots of farm crops, it becomes necessary to drain the soil in order to let in air.

80. **Soil Drains.**—The simplest method of draining surplus water from land is to dig ditches in the field, so that the water in the soil will seep into these open ditches, and to so plan the ditches that they lead the water off to a creek or other natural drain near by. The depth of these drainage ditches and their distances apart in the field should vary according to

the nature of the land. The usual ditches are from two to three feet deep and located from fifty to one hundred feet apart. The planning of these ditches may be easily learned from the references given. While open ditches will drain the land, they take up a deal of space, interfere with cultivation, and require frequent cleaning out. They should be made with sloping sides and when not very deep should be made so sloping that they can be driven across. In order to avoid the disadvantages of open ditches, underground tile drains are coming to be used more and more. These tiles are usually made of earthenware, in short, open joints, and are laid in trenches at about the same level that the bottom of an open ditch would be placed. The tile is then covered completely, and the trench filled up even with the surface of the soil so that the entire field may be cultivated. The free water as it settles down goes into these drains, which are so planned as to lead the water gently off down the hill to some natural drain. The method of laying these is easily understood from Figure 62. When the drains are laid, a carefully prepared diagram should be kept showing the exact location of each drain, as occasionally these tiles become choked by roots, and have to be opened and cleaned out. If no chart is made when they are laid, it is difficult later to find a pipe when repairs are needed. In certain districts great drainage canals

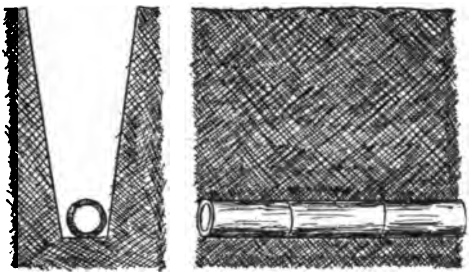

Fig. 62. The method of laying tile drains.

are dug, and all the surrounding fields are drained into these. The details of these large drainage plans you can learn, too, from your references.

81. **Effects of Drainage.**—Drainage has several good effects. First, it lets air into the soil and thus promotes growth; second, it makes the soil warmer, and because of the warm air being able to circulate deeper in drained soil it warms up quicker and is sooner ready for planting in spring; third, it enables the crop to stand drought better. At first this seems strange, but it is easy to understand. In the poorly drained soil the roots stay near the surface, as they cannot get sufficient air lower down. Later in the season, when drought comes and the water is dried out of the top soil, the plant starves because it has no roots down in the deep, moist soil. When the free water has been properly drained out of the soil, the plant roots go deeper down into the soil, and hence, when the drought dries out the top and the upper roots can get no food materials, these lower roots deeper down in the still moist soil can continue to supply the plant.

82. **How to Keep Bacteria and Plant Food Materials in the Soil.**—We have seen how the needed supply of water and air can best be kept in the soil. If we can learn now how to keep a supply of bacteria and of plant food materials in the soil in such form that the plants can use them, the growing of our crops will be put upon a safer basis. Let us now see how this can be done. The supply of bacteria and the supply of plant food material are so closely connected with each other that they can best be considered together.

83. **How the Soil Is Exhausted.**—Before we can intelligently plan to keep a supply of food materials in the soil and prevent its becoming exhausted, we must learn what it is that

causes exhaustion of the soil. The first step in remedying an evil is to remove the cause of the trouble, but before we can do this, we must find out what the cause is. Most people think that the taking of the crop from the land is the cause of its exhaustion. The crop does take food materials from the soil, but this is only one of four main causes of loss of fertility. Soil unwisely handled may lose a great deal more from other causes than from the removal of the crop. The four main causes of soil exhaustion are: (1) surface washing, (2) leaching, (3) loss to the air, and (4) loss through removal of vegetation. Let us now see how each of these takes place, and how it may be prevented.

84. **Loss by Surface Washing and How to Prevent It.**—You have all seen the muddy water flowing off after a rain. This water is carrying away quantities of soluble food materials dissolved in it, as well as quantities of small particles of the soil itself. The faster the water moves the larger the amount and the larger the size of suspended particles it carries. On steep hillsides in many cases the entire soil is in this way carried away to the streams and lowlands.* To prevent this surface washing, the first thing to do is to open up the soil and get plenty of humus in it. This will enable more of the rain to soak in and leave less to wash away. Next, the land should be terraced, or protected with hillside ditches, and the crop

* Professor Salisbury says: "It has been estimated that the Mississippi River carries to the Gulf more than 400,000,000 tons of sediment each year, or more than a million tons a day. It would take nearly 900 daily trains of 50 cars each, each car carrying 25 tons, to carry an equal amount of sand and mud to the Gulf. . . .

"The amount of matter carried to the sea in solution each year by all the rivers of the earth has been estimated at nearly 5,000,000,000 tons. This is about one-third as much as the sediment carried by the rivers."

rows run so that the water will flow around the hill and run off more slowly. If the water is delayed longer on the soil, more of it will soak in, and the amount of material it can carry is lessened. Even after all terracing and ditching that are practicable are used, some land is still so very sloping that the soil washes badly when cultivated. All such land should be covered with a sod and used for pasture, orchard or forest, the roots of the sod and trees being the best means of holding the land. The sod should contain such plants as Bermuda grass and Japan clover, which grow in warm months, and others which grow in the cold months, such as bur-clover and rescue-grass.

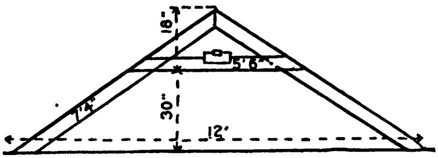

FIG. 63. An inexpensive home-made level with which terraces may be laid out.

85. **How to Make a Terrace.**—A terrace is simply a bank of soil extending around a hillside and so constructed that it is level, or nearly so, all along. The effect of this long level bank is to stop the surface water as it rushes down the hill. This delayed water then runs along the upper side of the terrace and accumulates until the top of the water reaches the top of the terrace. Then the additional water flows over the terrace all along in a thin sheet. In this way it goes more slowly and does not wash the land as it does when rushing down in narrow streams. Simple terraces may be laid out by any thoughtful boy with the cheap-home made terrace level shown in Figure 63. Start at the top of the hill and with the aid of your level find a spot that is three feet lower than the top. Then, from this spot as a starting point, run a line around the hill, keeping it always practically level with the starting

point. Place stakes along to mark this line. This will be the line of your first terrace. Then find a spot three feet lower than this line. Lay off your second terrace line on a level with this spot. Continue in this way laying off terrace lines until you reach the bottom of the slope. On very steep hill-sides it may be necessary to make your terraces with more than three feet drop, but this is usually undesirable. Having all your terrace lines now staked out, run a furrow along each, following the stakes closely. Leave about two feet of hard unbroken ground below this furrow, and upon this hard ground throw furrows from each side until a fair-sized bank is made all along the line. Wherever for any reason the bank is not level after the plowing, it must be finished with other tools until the top of the entire bank is practically level and the bank is about equally strong all along. Sow on this bank seeds of rapidly growing plants with strong fibrous roots that will hold the bank together, such as peas, clover, or oats. It is especially desirable that some winter growing plant should also grow on these terraces to strengthen them against the winter rains.

86. **Loss by Leaching.**—In addition to the surface water, the free water that fills the pores of the soil after each rain and passes on down dissolves great quantities of soluble food materials present and carries these down below the reach of the roots of ordinary farm crops, or carries them out to the valleys and empties them into the streams. Disintegration is going on all the time in the soil, and soluble food materials are being formed. If no crop takes these up before a heavy rain comes, they are dissolved in the free water and largely carried away. In the winter months when the heavy rains usually fall, many fields have no crops growing on them to utilize the

soluble food materials present, so these are leached out and lost. In many cases more is lost this way each year than is consumed by the crop.

87. **How to Prevent Leaching.**—The means of preventing leaching are very similar to those for preventing washing. Deep breaking of the land and filling it with humus so that it will hold more of the water in its pores by capillary attraction is the first step. In addition to this, we should see to it that at practically all seasons of the year some crop is growing on the land, so that the soluble food materials may be taken out of the soil as soon as they are formed and utilized by the plants, and not left to be leached away by the rains. Our mild climate favors the action of bacteria and the rapid disintegration of the soil and the making of soluble food materials during fall and winter and early spring. We should therefore keep our fields covered during these seasons with grains, other grasses, clovers, and similar cover crops, in order to save our land from leaching.

88. **Loss of Nitrogen to the Air.**—In addition to the loss of food materials to the water, at times large quantities are lost to the air. The harmful bacteria which tear down the soluble nitrogen compounds* set free a quantity of nitrogen which escapes into the air. These denitrifying bacteria flourish in soil that has an excess of water and a poor supply of air, and in soil that is acid. The means of preventing this loss are obvious. If wet, the soil should be well drained and opened up so as to hold an ample supply of air. If acid, the soil should have lime added to it to correct this acidity. The method of testing a soil to see if it is acid is simple. Dig down into the soil and press a piece of blue *litmus* (lĭt′mŭs) paper

* These are called *denitrifying* (dē-nī′trĭ-fī-ĭng) bacteria.

against the moist soil. If the soil is acid, the litmus paper will turn red or pink. The amount of lime needed depends upon how acid the soil is. From five hundred pounds to a ton or more per acre are used. After a certain quantity has been applied, and time allowed for it to be diffused through the soil, another test should be made, and the lime added until the soil is either *neutral* (nū′tra̤l) or slightly *alkaline* (ăl′kȧ-līn). Alkaline means the opposite of acid. Such a soil will turn red litmus paper blue. Neutral means neither acid nor alkaline.

89. **Plants Take Material From the Soil in Growing.**—Let us now see what the crop takes out of the soil. We plant about ten pounds of seed corn on an acre. If everything is favorable and a hundred bushels of corn are produced on this acre, that will give 5,600 pounds of corn and about 6,000 pounds of stover. The tiny embryos in that ten pounds of seed corn have therefore taken about 11,590 pounds of material from the soil and air. Plainly we cannot continue to take such enormous quantities of material out of the soil and air year after year and put nothing back without finally exhausting the supply. But before we can plan intelligently to put back, we must know what the substances are which the plant uses.

90. **How to Find Out What the Plant Uses in Growing.**—It is not easy to find out of what a plant is made. You or I can tear a pie to pieces and see that it is made of apple and sugar and flour, but if we then try to find what the flour is made of, we have to use a microscope to recognize the tiny starch cells, the gluten, and other parts. There we have to quit, but a trained chemist can take the starch or gluten, or a drop of the water in the apple, and tear each of these apart by delicate operations and learn what they are made of. He can, as you

know, run a current of electricity through the water and split it up into the two gases hydrogen and oxygen. At last, even the chemist comes to something that he cannot split any further, as, for instance, the hydrogen and oxygen. The tearing up of a compound and finding what it is made of is called *analysis* (ȧ-năl′ĭ-sĭs), and the place in which such work is done is called a *laboratory* (lăb′ō̆-rȧ-tō̆-rў). You know that any substance that can be analyzed into two or more simpler things is called a compound, and one that is absolutely simple and cannot be analyzed further is called an *element*. Iron, silver, gold, carbon are some of the elements with which you are familiar.

91. **Only Ten Important Elements in Plants.**—There are less than eighty elements in all the world, everything we know being one of these elements or a combination of them. Strange to say, it has been found that all plants and all animals are made of the same elements. Of these elements there are ten especially important ones. Other elements are found in animals and plants, but the following ten are the necessary ones, without which no plant or animal can live:

Carbon	Nitrogen	*Magnesium* (măg-nē′zhĭ-ŭm)
Oxygen	*Phosphorus* (fŏs′fō̆-rŭs)	*Calcium* (kăl′sĭ-ŭm)
Hydrogen	*Potassium* (pō̆-tăs′sĭ-ŭm)	Iron
		Sulphur

92. **Only Three Elements in Danger of Exhaustion.**—The carbon, oxygen, and hydrogen make up ninety-five per cent of the plant. As these are secured from the air and water, we need not consider them further here. The supply of carbon dioxide is practically inexhaustible, as all animals are constantly breathing out a fresh supply into the air. It is esti-

mated that the human race alone gives off more than 50,000,000 tons of this gas per day. The supply of water has already been considered. The calcium, iron, sulphur, and magnesium are used only in small amounts, and are usually in the soil in practically inexhaustible quantities, so that these four also need not concern us. Occasionally calcium is needed. This is easily supplied in the form of lime, which is a calcium compound. The three elements, nitrogen, phosphorus, and potassium, are used in considerable quantities, and all soils are liable to be exhausted of one or more of these if not intelligently handled.

93. **How Plants Exhaust the Soil of Nitrogen, Phosphorus, and Potassium.**—Every hundred-bushel crop of corn takes out of the soil 150 pounds of nitrogen, the amount of phosphorus found in 52 pounds of phosphoric acid (a compound of phosphorus), and the amount of potassium found in 85 pounds of potash (a compound of potassium). The cotton crop which produces a 500-pound bale takes out of the soil 100 pounds of nitrogen, the phosphorus found in 40 pounds of phosphoric acid and the potassium found in 65 pounds of potash. Similarly all other plants take these elements in large quantities out of the soil. On the other hand, analysis of soils has shown only a limited quantity of these substances in the soil. Analyses made of 49 soils in different parts of America showed an average of 3,000 pounds of nitrogen, 4,000 pounds of phosphoric acid, and 16,000 pounds of potash per acre. A bale-to-the-acre crop of cotton takes out 100 pounds of nitrogen. You can see that at this rate such a crop would exhaust the soil of nitrogen absolutely in thirty years, if it could be grown that long, and if no fresh nitrogen were put into the soil. A hundred-bushels-to-the-acre crop of corn would, under similar

conditions, exhaust the nitrogen in twenty years. If the nitrogen were exhausted, no plant could grow, no matter how much of other food materials remained, as plants cannot live without nitrogen.

94. **The Nature of the Soil Tends to Prevent Permanent Exhaustion.**—Fortunately, the complete exhaustion of the soil is not as easy as the above would suggest. Two things tend to prevent this: the nature of the soil itself, and the work of the wise farmer. The nitrogen and other elements in the soil are never all in a condition in which they can be used by the crop at one time. The plant can use only so much of the material as is in a soluble form, so that it can be taken in by the root hairs. The material that is in a condition to be used by the plant is called *available food material.* Only a part of the total food material in the soil is at any one time available. If a field that has been exhausted by continued cropping is allowed to rest a few years, it will produce again, because disintegration will have gone on in the soil and some more of the food material will have been changed into available form. Food materials will have been prepared also by the bacteria. The soil thus tends to save itself and renew its own fertility. This is, however, a very slow and expensive process. The farmer can, by intelligent handling, prevent the land ever needing a rest. Indeed he can gather profitable crops each season, and still make his soil richer and richer each year, if he will arrange to supply the soil with the needed nitrogen, phosphorus, and potash.

CHAPTER V

MANURES, FERTILIZERS, AND ROTATION

95. How the Farmer May Add Plant-Food Materials to His Soil.—Let us now see how the farmer may most economically add to the supply of food materials in the soil. The principal methods of doing this are: 1, turning under stubble and other vegetation; 2, adding manures; 3, adding fertilizers; 4, growing special crops that encourage nitrogen-fixing bacteria. We shall now study each of these methods.

96. Turning Under Stubble and Other Vegetation Adds Food Material.—Fortunately, the part of most of our field crops which is sold contains only a portion of the food material taken from the soil by the plant. In cotton, for example, only about one per cent of the material that made the lint came from the soil, so that if the farmer returns the stalks and seed, the soil will get back nearly all that it lost. The stalks which bore the lint in a five-hundred-pound bale alone contain food materials that would cost about nine dollars if bought as fertilizer to add to the soil. The

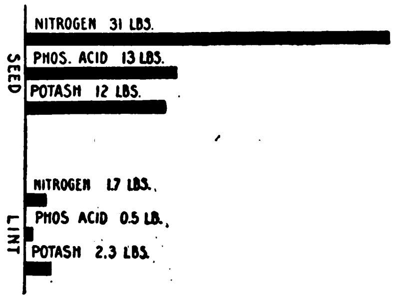

FIG. 64. Showing the large amounts of nitrogen, phosphoric acid and potash used by 1,000 pounds of cotton-seed and the very small amounts used by 500 pounds of lint cotton.

seeds are, however, much richer in the needed food materials. Figure 64 shows you the large amounts of nitrogen, phosphoric acid, and potash taken away in the seeds. The plant-food materials in the stalks of a hundred-bushel corn crop after the grain is harvested would cost, as fertilizer, over eighteen

Fig. 65. On the left no manure or fertilizer used and no corn produced. On the right 15 tons of horse manure used with yield of 65 bushels per acre.

dollars. The plant-food materials in the stubble and straw of a thirty-five-bushel crop of oats are worth over thirteen dollars. The facts are similar in the cases of other crops. This shows how very important it is to turn back under the soil all stubble and stalks before they lose a great part of their value by decay and by giving off nitrogen into the air. In addition to the plant-food materials added directly by the turned-under vegetation, we have already seen that by encouraging the growth of bacteria, and through other effects on the soil, the humus adds perhaps even more to the available supply of food materials indirectly than it does directly.

Recall these effects and consider them again. The farmer, then, who burns his stubble and straw is burning money, for when vegetable matter is burned nearly all its fertilizing value is wasted, leaving little except the small amount of potash in the ashes.

97. **Manure: What It Is and What Are Its Values.**—A large part of our farm crops is fed to animals. Of the elements in this food which the plants took from the soil dissolved in water, the animal retains in its body only about fifteen per cent, giving back in its manure eighty-five per cent. The manure consists of the solid dung and the liquid urine. The urine contains more than twice as much of the valuable elements per ton as does the dry manure. The value of manure for fertilizing depends upon the animal from which it comes and the food which the animal has eaten. Horse manure is richer than cow or hog manure, but not so rich as sheep or poultry manure. A ton of horse manure contains from seven to twelve pounds of nitrogen, five to eight pounds of phosphoric acid, and nine to twelve pounds of potash, depending largely upon the foodstuffs used. At the price now paid for these fertilizing materials, the amount in a ton of manure would be worth from $2.25 to $3.60. You have already seen that the manure, in addition to the value of the food materials which it contains, is of perhaps greater value to the soil in holding moisture, keeping the pores open, adding useful bacteria, supporting those already there, and in giving off acid gas that helps with the dissolving of the rock particles. In experiments carried on for several years in New York and Ohio, it was found that the crops of hay and oats yielded $2.58 worth of additional produce for each ton of manure put upon the land, while crops of wheat, clover, and potatoes yielded $2.96 worth for each ton.

These figures by no means measure the full value of the manure, because a large part of the fertilizing value of manure remains in the soil many years. This is proved by experiments at Rothamsted, England, where a field continued to give an increased yield from the effect of long use of manure for thirty years after the manure was applied. Two fields, as nearly equal as could be found, were cultivated alike for twenty years. On one, fourteen tons of manure per acre were used annually. On the other no manure was used. For the following thirty years both were cultivated alike again, no manure being applied to either. At the end of this time the effect of the manure was still being shown. The land which had been manured produced on the average for the last ten years 2,900 pounds of grain to 1,300 pounds produced by the unmanured land.

98. **Amounts of Manure from Different Animals.**—The manure produced each year for each thousand pounds weight of the animal or animals is shown by Roberts to have approximately the following values: horses, $42; cows, $39; sheep, $46; hogs, $80. The total amount produced by each kind of animal is shown in the following table:

	DRY MANURE	LIQUID MANURE
Horse	12,000 lbs.	3,000 lbs.
Cow	20,000 "	8,000 "
Sheep	760 "	380 "
Hog	1,800 "	1,200 "

99. **How the Value of Manure Is Lost.**—The first waste of manure results from the failure to save the liquid manure. If the urine is not saved, about half of the value of the

manure is lost. The next waste occurs when the manure is left out in the weather or is not kept properly covered or sufficiently wet. A large part of the valuable food materials in the manure is in soluble form, so that if the manure is left in the rain these are leached out and carried away in rain-water. Some of the nitrogen is changed to ammonia and passes off to the air in the form of a gas. A large part of the other materials of the manure which are so valuable in loosening the soil and supporting soil bacteria is slowly changed by the oxygen of the air and lost when manure is left exposed. If the manure is allowed to become dry, these changes and this waste go on more rapidly. In tests made at the New Jersey Experiment Station manure exposed to the weather lost over fifty per cent of its value in four months. At the Ohio station exposed manure when used on a crop was found to have a value of $2.15 per ton, while the value of stable manure was $2.96. When twenty-three cents' worth of acid phosphate was added to the stable manure its fertilizing value was $4.80 per ton. At Cornell 4,000 pounds of manure were exposed from April 25 to September 25, at which time it weighed only 1,730 pounds. The nitrogen in this manure had fallen from 19.60 to 7.70 pounds, the phosphoric acid from 14.80 to 7.70 pounds, the potash from 36 to 8.65 pounds. The value of the plant-food materials had fallen from $6.46 to $2.38, a loss of sixty-three per cent.

100. **How to Save Manures.**—The first thing to do toward saving all the value of manure is to save the liquid manure, either by having a water-proof floor in your stable or by keeping sufficient litter in the stable to absorb all urine. All manures should be kept under cover until hauled to

the field, and never allowed to lie exposed to the air and rain. Even under cover the manure needs attention. It should be packed down to press out the air and retard the action of bacteria, and kept wet enough to prevent heating, which drives off nitrogen. Even when properly wet, there will be some giving off of nitrogen, and in order to save this, the manure heap should be covered with loam, sawdust, or straw. Loam is best, as this absorbs thirteen pounds of nitrogen to the ton, whereas sawdust absorbs eight and straw only four. Still better results are obtained from manure if a compost is made. The United States Department of Agriculture gives the following directions for making a compost heap and applying the compost to the land.

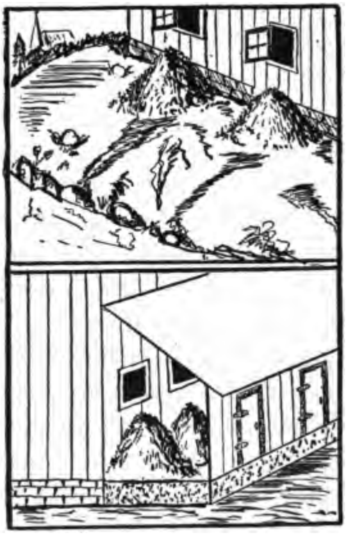

Fig. 66. The top picture shows the usual method of saving manure, by which about one-half of its value is lost by leaching and by giving off nitrogen to the air. The stable at the bottom has a cement floor to save the valuable liquid manure, and a cover to protect the manure from rain and leaching. This farmer also wets the manure occasionally, adds rock phosphate, and covers the pile with loam and straw to catch the nitrogen that is set free.—*After Duggar.*

101. **How to Make a Compost Heap.**—"Locate the compost heap in an old shed, or build a shed, with any kind of cheap material for a roof. Spread on the ground a layer of stable manure 8x10 feet, 6 inches deep. Over this spread 100 pounds of acid phosphate or ground phosphate rock. The phosphate rock

answers as well as the acid phosphate and costs about half as much. Continue these alternate layers until the manure is used up, or until the pile has become inconveniently high. To these layers might be added straw, leaves, mould, or other litter, adding 100 pounds ground phosphate rock to each ton of material used. Be sure to wet all thoroughly. When the compost heap is completed, cover it about 4 inches deep with good loam or with forest mould.

102. **How to Apply the Compost.**—"When applying two tons per acre or less, the best results can be obtained by putting the compost in the furrow and bedding out on it. Be careful not to bury too deep, especially on clay soils. When using more than two tons per acre, it is better to scatter broadcast.

"Bearing in mind the supplemental value of the cow-pea, it is safe to say that by using compost at least fifty per cent can be added to the productiveness of the average one-hundred-acre farm, and that simply at the cost of a few tons of acid phosphate and a little labor. With the barn-yard manure and with the cow-pea at his service to save and gather nitrogen for him, the average farmer is simply wasting his money when he continues to buy nitrogen in commercial fertilizer when he could easily produce all that his land needs upon his farm."

103. **Green Manures.**—In addition to turning under stubble, it is sometimes advisable to turn under an entire crop. The green crop thus plowed under is called *green manure.* Green manuring provides a method of rapidly adding humus to the soil. Among the best crops for this purpose are cow-peas, velvet-beans, soy-beans, clover, and sorghum. Usually crops should be fairly mature before being turned under.

Such green manuring should not take place immediately before the planting of a new crop, especially one of small grain. Cover crops are frequently sown in the fields at the last cultivation, grazed during the winter, and turned under in the spring. This is an especially valuable practice, as it furnishes grazing, saves the land from loss of fertility in winter, and adds valuable humus besides. All green manure should be turned under at least two weeks before the new crop is planted.

104. **Green Manure or Stock Feeding.**—The question is often asked whether it pays better to plow under a crop or feed it to stock, put the manure on the land, and sell the stock. This depends upon so many circumstances that no general answer can be given. As over eighty per cent of the fertilizing elements of the crop is left in the manure after being fed to stock, it is usually wise to pass the crop through stock before putting it into the soil. But, if the soil is very low in organic matter, the quickest way to replenish this is to plow under an entire crop, as more than fifty per cent of the organic matter is lost when fed. In each case one would have to consider the needs of the soil, the work involved in each method, the access to markets, and other factors before he could intelligently decide which procedure would pay best. This will be further discussed under Animal Husbandry.

105. **Plants that Add Nitrogen to the Soil.**—Although there are millions on millions of tons of free nitrogen in the air and circulating in the soil, four-fifths of the air being nitrogen, plants cannot use this as food material. It must first be made into a soluble compound. You have learned that certain bacteria in the soil can take free nitrogen and help to make it into a soluble nitrogen compound. The

scientists have found that there are certain plants upon the roots of which these nitrogen-fixing bacteria thrive. These plants are the *legumes* (lĕg'ūmz), such as peas, clovers, peanuts, alfalfa, bur-clover, soy-beans, velvet-beans, and vetch. If you will examine the roots of these plants, you will see little wart-like nodules scattered over them. These are called *tubercles* (tū'bĕr-klz), and contain millions of these bacteria. The plant feeds on the nitrogen compound made by the bacteria on its roots, and deposits the nitrogen in its stem, leaves, roots, and fruit. If the whole plant is later turned under, all this soluble nitrogen is added to the soil. When the pea-vines that would produce a ton of hay are turned under, $10.00 worth of plant-food material is added to the soil. The roots alone, if left in the soil, add greatly to its fertility, as about thirty per cent of the plant-food material is in them. The growing of legumes and the production of barn-yard manure offer the most economic method by which the farmer may steadily improve his land and increase his income.

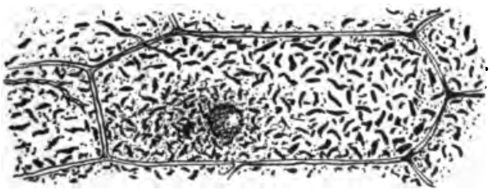

Fig. 67. This shows the nitrogen-fixing bacteria in the cells of the root tubercle of a legume.

106. The Most Deficient Food Element Sets the Limit of the Crop.—We know that one variety of crop uses more of one substance and another variety uses more of some other substance. We know also that some land is well supplied with one substance but lacking in some other. In such a case the material of which there is a plentiful supply

cannot be used by the plant any longer than the supply of the deficient element holds out. For example, if a soil is deficient in nitrogen but well supplied with potash and phosphorus, the crop can use no more of the potash and phosphorus after the small supply of nitrogen has been used up, because the plant can make no new growth unless its food contains its proper proportion of nitrogen. There may be enough potash and phosphorus in a soil to produce one hundred bushels of corn to the acre, but if there is only enough nitrogen to produce twenty bushels, then that is all the field will yield. The most deficient element sets the limit of the crop.

Fig. 68. This shows the tubercles on the roots of a soy-bean.
Courtesy of the U. S. Department of Agriculture.

107. **What is a Commercial Fertilizer?**—What has been said above shows why at times it is more economical to supply just one food element rather than to add a manure which contains many elements. At other times special combinations of elements can be got together that meet the needs of a particular soil and a special crop more economically than would manure. If we have a field slightly deficient in phosphoric acid, but amply supplied with nitrogen and potassium, then we should merely waste the seven pounds of nitrogen and nine pounds

of potash in the manure if we applied a ton of manure in order to secure the five pounds of phosphoric acid in it. To meet such conditions artificially prepared materials are applied to the soil for the purpose of supplying the especially needed plant-food material or materials. Such artificially prepared materials are called *commercial fertilizers.* While occasionally other elements need to be supplied, practically all fertilizers supply either nitrogen, potassium, or phosphorus, or some combination of these. We shall now give the names and a brief account of the chief materials used in commercial fertilizers, show how to calculate the value of mixed fertilizers, how to find out what fertilizers to use, and how to prepare them.

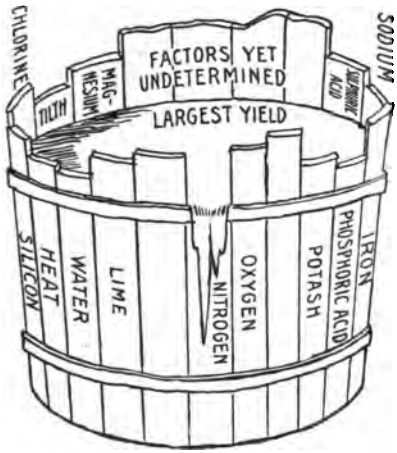

Fig. 69. Just as the tub can be filled no higher than the shortest stave, so the crop can grow no larger than is allowed by the most deficient necessary element in the soil.—*After Halligan.*

108. **Fertilizers That Supply Nitrogen.**—The usual commercial fertilizers furnishing nitrogen are *sodium nitrate, sulphate of ammonia, cotton-seed meal, dried blood,* and *tankage.* Nitrate of soda is found on the west coast of Chile. It contains about fifteen per cent of nitrogen in a very soluble form, and therefore should be added only in small amounts and while the plants are growing. If put on the soil long before

the plants are ready to use it, the nitrate will be dissolved and washed away by the rain. When spread broadcast over the ground, it is so rapidly dissolved and carried down by the moisture in the soil that young plants will show the effect of it and become greener within a week of the time it is applied. It is especially valuable for use with plants growing during the cool weather. Sulphate of ammonia is obtained from coal, and contains about twenty per cent of nitrogen. It does not wash out of the soil so readily as nitrate of soda. Cotton-seed meal is what is left of the cotton-seed after the oil and hulls are removed. It contains nearly seven per cent of nitrogen, together with some phosphate and potash. As the meal must decompose before the nitrogen is in a form that the plant can take in, it should be put into the ground before the crop is planted or at the time of planting. Dried blood and tankage are materials coming from slaughter-pens, the blood containing eight to thirteen per cent and the tankage six to ten per cent of nitrogen. These must be changed in the soil also before the plant can use them, and hence are usually applied to crops that have a long growing season.

109. **Fertilizers Supplying Phosphoric Acid.**—The principal source from which the phosphorus in commercial fertilizer is obtained is *rock phosphate.* Beds of this are found in Tennessee, South Carolina, Florida, and Canada. This rock is ground and sold as *raw phosphate.* In this condition it is not soluble in pure water, and hence cannot furnish the plant-food material, but in a soil supplied with bacteria and humus it is slowly changed into a soluble form and affords the cheapest supply of phosphate for the crop. It must, of course, be placed in the soil some time before it is needed by

the crop. The ground phosphate rock may also be treated with sulphuric acid before being put into the soil, and in this way the phosphorus ehanged to soluble form. Rock that has been so treated is sold as *acid phosphate,* and contains usually from twelve to sixteen per cent phosphoric acid. This, although soluble, does not leach out of the soil so readily as a nitrate, and is best applied before or at the time of planting. Bones are another source of phosphatic fertilizer. Bone is sold ground as *bone meal,* steamed as *steamed bone,* and burned as *bone ash.* The raw bone contains eighteen to twenty-two per cent phosphoric acid and two and one-half to three and one-half per cent nitrogen. Steamed bone and bone ash contain more of the phosphoric acid.

110. **Fertilizers Supplying Potash.**—The important materials supplying potash are *kainit, muriate of potash,* and *sulphate of potash.* Kainit contains twelve to fifteen per cent potash, and the other two about fifty per cent each. These are readily soluble.

111. **How Fertilizers Are Valued.**—The laws of Texas and many other States require that all commercial fertilizers be plainly labelled. The label must state what per cent of the different food materials the manufacturer guarantees to be in the fertilizer. The State chemist each year finds what each of the fertilizing materials costs at retail in the large markets of the world and publishes this price as the standard of value for that year. For instance the standard values set for 1910–11 were:

	CENTS PER LB.
Available phosphoric acid in mixed fertilizers and bat guano	6
Total phosphoric acid in tankage and bone	4
Nitrogen in mixed fertilizers and bat guano	20
Nitrogen in bone and tankage	19
Potash	6

With these prices known it is easy to tell the value of a mixed fertilizer. For example, if a ton of fertilizer contains four per cent available nitrogen, eight per cent available phosphoric acid, and two per cent potash, its value can be found as follows:

1 ton = 2,000 lbs.			
4% of 2,000 lbs. = 80 lbs.	80 lbs. nitrogen at	\$0.20 =	\$16.00
8% of 2,000 lbs. = 160 lbs.	160 lbs. phos. acid at	0.06 =	9.60
2% of 2,000 lbs. = 40 lbs.	40 lbs. potash at	0.06 =	2.40
		Total	\$28.00

In this way we learn that the ton of fertilizer contains 80 pounds of nitrogen worth \$16, 160 pounds of phosphoric acid worth \$9.60, and 40 pounds potash worth \$2.40, which gives a total value of \$28. This represents the value of the unmixed materials. A fair selling price would require that to this be added the cost of mixing, sacks, transportation, and a reasonable profit for the manufacturer. Before buying fertilizers one should write to the agricultural experiment station for the bulletin giving the fertilizer law, the valuations of materials for the year, and the analyses of the various brands sold in the State. The commercial value discussed above is no measure of the agricultural value of the fertilizer. It matters not what fertilizing materials may cost, if a ton of fertilizer caused an increase of forty bushels of wheat, and wheat sold at a dollar, the value of that fertilizer to the farmer would be forty dollars, less the additional expense of handling the fertilizer and the extra forty bushels of wheat.

112. **Complete and Incomplete Fertilizers.**—A fertilizer that contains nitrogen, phosphoric acid, and potash is called a *complete fertilizer*. One containing only one or two of

these is called *incomplete*. Most commercial fertilizers are complete or mixed. As each soil and crop is likely to have need of a different combination of the fertilizing materials it is usually best not to buy a complete fertilizer, but to determine first what the field needs and then to purchase these materials only and mix your own fertilizer.

FIG. 70. This shows the effect of the absence of nitrogen, potassium, or phosphorus. The pot on the left lacks potash, the next lacks nitrate, the next lacks neither phosphate, potash, nor nitrate, the last lacks phosphate.

Courtesy of the Texas Experiment Station, College Station, Texas.

113. **How to Determine What Fertilizer is Needed.**—By analyzing the soil and crop the chemist can tell what food elements they contain, and what the plant takes out of the soil. In this way he is of great help in finding out what fertilizer to use. But the effects of bacteria and of several other things which influence the crop are not considered when the chemist analyzes the soil and the crop, so that his analyses, while they help, cannot tell us exactly what fertilizer to use on a particular field with some special crop. This is more easily and correctly found out by making an experiment on a series of small plats in the field. If, for example, you wish to know

what fertilizer to use in a certain field for corn, select a part of the field that fairly represents the soil, and lay off side by side a series of plats of one-twentieth of an acre each and number them. Plant and cultivate the corn alike in each, but put different amounts and varieties of fertilizers on each plat in such a manner as is shown in the diagram below. The amounts to be used would vary with different fields and crops. The amounts in the diagram are given merely as illustrations.

1	2	3	4	5	6	7	8	9	10	11
No fertilizer	8 lbs. nitrate of soda	10 lbs. acid phosphate	No fertilizer	5 lbs. muriate of potash	8 lbs. nitrate of soda 10 lbs. acid phosphate	No fertilizer	8 lbs. nitrate of soda 5 lbs. muriate of potash	10 lbs. acid phosphate 5 lbs. muriate of potash	No fertilizer	8 lbs. nitrate of soda 10 lbs. acid phosphate 5 lbs. muriate of potash

The plats to which nothing is added show what the soil will do unaided. The crops on each plat will show just what effect is produced by each of the various amounts and kinds of fertilizers. If, for example, plat No. 2 showed no increase over the unfertilized land, what would that show as to whether the soil needed nitrogen? If the crop on No. 5 were better than that on No. 4, what would that show? If No. 9 were still better than No. 5, what would this show? By using various amounts and combinations of the materials one can soon learn just what a soil needs to grow any special crop.

FIG. 71. Millet grown on equal and adjoining areas. That on the left had no fertilizer and produced one ton per acre. That on the right was given 200 pounds of potassium chloride per acre and produced three tons per acre. The cost of treatment was five dollars per acre. The increase in the crop was worth forty dollars per acre.
Courtesy of Mr. Louis H. Klaas.

In addition to the use of experiment plats a great deal can be learned by looking at the growing crop. If the crop is small and pale, the soil needs nitrogen. If the stalks and leaves are vigorous and green, but the plant is deficient in fruit, there is plenty of nitrogen, but phosphate is needed, as this promotes fruitage and early ripening. If the stems are weak and the plants tend to drop their fruit, potash is probably needed, as this also helps directly in developing the fruit and promoting the general vigor of the plant. All of these signs are useful to know, but they do not always hold, as other causes may also produce the same appearances as those mentioned above.

114. **How to Mix Fertilizers Accurately.**—Let us suppose that as a result of the fertilizer test it was found that our soil needed 160 pounds of 15 per cent nitrate of soda, and 200 pounds of 14 per cent acid phosphate per acre. As 15

Fig. 72. On the right no manure or fertilizer used, and no corn produced. On the left 200 pounds of potassium chloride used, with yield of eighty bushels per acre.

Courtesy of Mr. Louis H. Klaas.

per cent of 160 is 24, and 14 per cent of 200 is 28, we see that our soil really needs 24 pounds of nitrogen and 28 pounds of phosphoric acid per acre. Now suppose, instead of using nitrate of soda to supply the nitrogen and acid phosphate to supply the phosphoric acid, we wished to use cotton-seed meal to furnish the nitrogen and steamed bone to furnish the phosphoric acid. Let us then see how many pounds of cotton-seed meal will be required to furnish 24 pounds of nitrogen, and how many pounds of steamed bone will be required to furnish 28 pounds of phosphoric acid. In 100 pounds of cotton-seed meal we know that there are 7 pounds of nitrogen. In order to secure 24 pounds of nitrogen we

must take as many hundred pounds of meal as there are sevens contained in 24 ($24 \div 7 = 3.43$). We therefore need 343 pounds of cotton-seed meal. Likewise, we know that in 100 pounds of steamed bone there are 30 pounds of phosphoric acid. In order to secure 28 pounds of phosphoric acid you would need as many hundred pounds of steamed bone as 30 is contained in 28, or twenty-eight-thirtieths of a hundred. Twenty-eight-thirtieths of 100 is 93. Hence we need 93 pounds of steamed bone. We see then that 343 pounds of 7 per cent cotton-seed meal are equivalent to 160 pounds of 15 per cent nitrate of soda, as a source of nitrogen, and that 93 pounds of 30 per cent steamed bone are equivalent to 200 pounds of 14 per cent acid phosphate. In this way it is easy to mix your own fertilizers at home, and secure just what is desired without paying for other materials that your land may not need, paying the manufacturer's profit and the freight on the useless material put in as a "filler" in mixed fertilizers.

115. **Rotation of Crops.**—Each crop takes certain kinds of matter out of the soil, some taking more of one element and some more of another. If any crop which took a great deal of a certain element out of the soil were grown year after year on the same land, you can easily see what would result. Seeing what would necessarily result, the wise farmer does not grow the same crop on his land year after year, but follows one crop with a different kind that draws largely from a different element in the soil, or encourages the growth of favorable bacteria which enrich the soil. The following of one kind of crop by a different one in a regularly arranged order is called *crop rotation* (rō̇-tā′shŭn). There is no one best rotation for all farms, as this depends on the nature of the soil, the climatic conditions, and the system of

farming; that is, whether it is a stock farm, dairy farm, cane, grain, or diversified farm. Under any system of farming, the wise farmer must practise rotation, but he himself must study out the best system of rotation for his situation. The following general principles should be followed: 1, the succeeding crops should take different elements from the soil; 2, each crop should leave the land in good condition for the following crop; 3, some of the crops should put back into the soil humus and needed food materials, such as nitrogen; 4, the land should never lie long bare to be blown or baked, or have the plant food in it washed out by heavy rains.

116. **A Good Three-Year Rotation.**—The following is a good three-year rotation well suited to most Southern farms:

First year, cotton, followed by a cover crop, such as burclover or rescue-grass.

Second year, corn with cow-peas or soy-beans sowed in the rows at the last cultivation. In very dry sections the legumes are sown sooner.

Third year, oats, followed by cow-peas or pea-nuts. If the farmer wishes to grow more cotton or more corn this crop is grown two years instead of one, making a four-year rotation.

117. **Advantages of Crop Rotation.**—The practice of a well-planned rotation of crops has the nine following advantages:

1. It keeps the soil in better mechanical condition for plant growth. The continuous growth of one crop, such as cotton or corn, causes the soil finally to run together and get hard.

2. Crops differ as regards their food requirements. Certain crops would remove from the soil large amounts of one

element, whereas other crops would remove large amounts of a different element. In growing different crops, no one element is so rapidly exhausted from the soil.

3. Some plants increase the supply of organic matter and nitrogen-fixing bacteria in the soil. This is true of legumes, such as clover, pea-nuts, and cow-peas. A rotation of crops will permit the growth of these soil-improving crops.

4. Some plants are deep-rooted, while others are shallow-rooted. By alternating the deep-rooted with the shallow-rooted plants, a portion of the food materials in the subsoil is used.

5. Where crops are grown in rotation, less commercial fertilizer is needed. That which is applied will bring more profitable returns than where no rotation is practised.

6. A good rotation provides for making more manure, because it grows crops for the feeding of live-stock. The wise farmer does not sell his hay and roughage, but feeds it to animals and sells the animals. The animals bring in the cash, and, in the manure they make, leave eighty per cent of the plant food to be put back into the soil.

7. Plant diseases and insect enemies do less damage when crops are grown in rotation.

8. When one crop has been grown on the same field for many years, it sometimes ceases to thrive in that soil. This fact is, in certain cases, due to a kind of soil sickness, which is now thought to be probably caused by poisons which that particular crop gives off to the soil.. While these poisons hurt this particular crop, they do not necessarily harm others, therefore their injurious effects are avoided by rotation.

9. A good rotation gives the farmer an income during all seasons of the year, as well as keeping his labor profitably employed all the year.

118. **Results of Experiments in Rotation.**—At the Louisiana Experiment Station a three-year rotation, consisting of first year corn, second year oats, followed by cow-peas, third year cotton, was carried out for eleven years. At the end of this time the yield was from twelve to twenty-five per cent greater than at the beginning of the rotation. This was where no manure was added. In a part of the field in which manure was added, the increase was still greater. At the famous Rothamsted Experiment Station, in England, wheat was grown for forty-eight years without rotation in one part of a field, and in another part it was grown in a four-year rotation for the same time. The average yield per year for the twelve crops grown in the rotation was 28.6 bushels per acre, while the average yield for the same twelve years on that part of the field on which rotation was not practised was only 12.6 bushels per acre. In a similar experiment there, barley yielded in

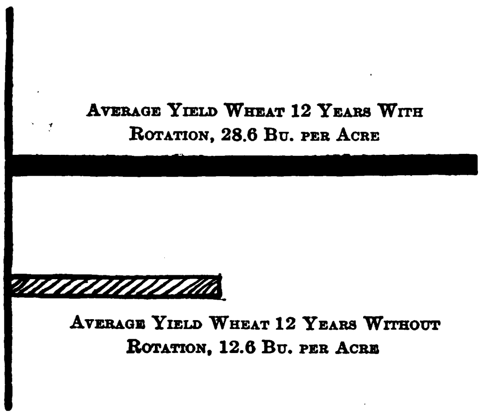

Fig. 73. This shows the yield of wheat, with and without rotation, at Rothamsted Experiment Station, in tests extending over forty-eight years.

rotation an average of 2,960 pounds per acre, but without rotation yielded only 1,735 pounds per acre.

The farmer who does not practise rotation, then, greatly lessens his yearly income from his farm, and gradually exhausts his soil, thus making the farm less and less valuable each year. On the other hand, the farmer who carries out a wisely planned rotation increases his yearly income, and, by building up the fertility of his soil, adds each year to the value of the farm itself.

QUESTIONS, PROBLEMS, AND EXERCISES

56. Find in your neighborhood an illustration of the following: 1, rock surface with no soil; 2, rock broken by expansion from heat; 3, soil made by water deposit; 4, soil made by vegetable decay.
57. Carefully weigh and record the weight of a vessel holding a gallon or more. Catch one gallon of muddy surface water that is flowing off after a rain. Put this in the weighed vessel, evaporate the water and weigh the vessel again with all dry deposit in it. How much solid material did that water carry per gallon?
58. Bring in samples of such soils as can be found in your neighborhood and classify them according to the varieties given in this chapter.
59. Make a rough outline map of your farm and show on this the location of the different kinds of soils. Dig down and measure the depth of the top soil and state what is the nature of the subsoil in each case.
60. Dig up some subsoil and fill one pot, powder some rock and fill another, and fill a third with good top soil. Plant seeds of the same variety in each pot, and note and explain the result.
61. Melt the top from a large can and measure the amount of water it will hold. Then press this can, open end down, into the soil. Now dig around the can and take it out full of soil in its natural position. Strike the soil off level with the top. Then slowly add water from your measuring-glass until the can is filled. What per cent of the total space in the can was taken up by the dry soil? What per cent of the soil space was taken up by air?

62. Using equipment similar to that shown in Figure 57, make a rough test of the per cent of water that can be held by clay, sandy loam, and one other local soil. Weigh the soil before placing in the vessel. Weigh a glass containing a little more water than the soil can hold. Pour the water slowly on top of the soil and set the glass at once beneath the vessel to catch any water that the soil will not hold. After the water has ceased coming through, weigh the glass containing the water that passed through and note how much the soil held in each case.
63. Using chimneys and vessel similar to those shown in Figure 58, find out how long it will take water to rise one inch, three inches, and six inches by capillary attraction in clay, fine sandy loam, and gravel, or three other varieties of soil in your neighborhood.
64. Fill three one-half gallon jars or cans with the same kind of soil to within two inches of the top, pressing soil down lightly. Pour in water till the soil is all well moistened, but no water stands on top. Cover one with two inches of dry sand, one with two inches of dust mulch, and leave the other as it is. Weigh all each day for ten days, and record the loss of water from each.
65. Lay a lump of loaf-sugar in a saucer that has coffee or other colored fluid in it. Watch the rate at which the fluid passes through the lump. Now place another lump on top of the first lump and note the effect of the larger air spaces between the two lumps in delaying the passing of the liquid into the top lump.
66. Take samples of different soils, moisten and work into mud balls, and allow these to dry. Which soils show most adhesiveness? Make a ball of clay. Using the same clay mixed with an equal amount of well-decayed organic matter, make another ball. Let them dry and note which sticks together better.
67. Fill two bottles two-thirds full of water, that in one being fresh, that in the other being boiled and oil-covered, as explained in paragraph 14, in order to shut out the air. Place a rose-cutting in each and note progress in rooting of each. What does this show?
68. Plant seeds in two cans containing the same kind of soil. As soon as the plants are up, keep the soil in one can soaked with water. Give the other water only every two days, allowing no free water to remain long in the soil. Make note of the results and explain them.

69. Notice whether bare or sod land loses more by washing in winter. Can you tell why land with a crop on it will also lose less in winter by leaching than that which is bare?
70. Construct a level like the one shown in Figure 63, and lay off terraces on a hill-side near by.
71. Make holes in the bottom of a large deep can, lay a thin cloth on the bottom, and fill the can two-thirds full of a mixture of good soil and nitrate of soda. Pour on water equal to a six-inch rainfall, catch the water that comes through the bottom, evaporate it and see how much has leached out of the soil.
72. With a clean spade or shovel throw out a shovelful of dirt in a field, press a strip of blue litmus paper against the freshly cut surface of the moist soil, and see if the soil is acid. Use a piece of red litmus paper in the same manner and find whether the soil is alkaline or neutral.
73. If four thousand pounds of manure after being exposed for six months weigh only one thousand seven hundred and thirty pounds, what per cent of its weight has it lost?
74. Apply two tons of manure to one acre in your field. Plant and cultivate this exactly as you do the acre next to it. Keep a record of the amount produced on each acre, and find out how much the manure added to the crop the first year. The second year add no manure to either acre. Plant and cultivate both alike again. Note how much the manure affects the crop the second year.
75. In your field apply well-rotted manure liberally to an experiment plat, and turn under in winter to decompose still further before the drought begins. Apply the same amount of unrotted manure to a similar adjoining plat, but put it in late. Note which resists the drought best: the soil without humus, that with well-disintegrated humus, or that with the rough unrotted manure.
76. In the experimental garden, or at your home, carry out the test shown in the diagram on page 122, and other similar tests.
77. To produce one hundred bushels of corn, one hundred and fifty pounds of nitrogen, fifty-two pounds of phosphoric acid, and eighty-five pounds of potash are required. How can you prepare a fertilizer to supply the above amounts of food materials, using cotton-seed meal, acid phosphate, and kainit or muriate of potash?
78. Can you think of another good reason for practising rotation besides the reasons given in this chapter?

79. Is this a good rotation: first year, cotton; second year, wheat, followed by corn; third year, oats, followed by cane? If not, what is wrong with it?
80. Plan a good three-year rotation for a farm that raises hogs and cattle, and is in the moist belt. Explain why your rotation is good.
81. Plan a good three-year rotation for the same kind of farm in the dry belt. Explain why this rotation is good.
82. Make a list for each of your father's fields, showing what has grown on it during each year for the last four years. Study the list for each field, and state whether the rotation practised was wise or not, and why.
83. Ask your father to allow you to carry out your three-year rotation on a part of his land. Keep an account of the profits from the land each year. Keep an account also for an equal number of acres of the same kind of land adjoining this plat on which no rotation is practised and compare results. Also note the fertility of each plat at the end of the rotation, as is shown by the crop of the following year.

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CHAPTER VI

TILLAGE AND FARM IMPLEMENTS

119. **Introductory.**—In our study of the soil we have learned that the proper turning and pulverizing of the soil make it much more favorable to the growth of the crop. Such fitting of the land for the more favorable growth of plants is called *tillage* (tĭll′āj). The earliest form of tillage was the breaking of the soil in order to plant the crop. Crops were planted broadcast and not cultivated. Early implements used in tillage were hoes made of shells tied to poles and forked sticks used as plows, drawn by men and women. Later better plows were made of wood and beasts of burden were used to pull them. Man learned to put an iron tip on his wooden plow over a thousand years ago, but progress has been so slow that such plows were still used about a hundred years ago. These were finally surpassed by the iron plow, which has been so rapidly improved during the past fifty years that we now have various forms of sulky plows and cultivators, and the great steam plows. These improvements have been made very largely by Americans, who lead the world in the invention and manufacture of farm implements. It is said that it required four and six-tenths days for the old Roman farmer to produce a bushel of wheat. With his new implements and methods, the American of 1830 could do this with three hours' labor, but the present-day American with yet better tools can do it with nine minutes' exertion.

120. **The Result of Improved Implements.**—The result of this lessening of labor and increasing of efficiency by improved implements has been to enable the intelligent farmer to raise far larger crops and still have a great deal more freedom from mere physical labor. By using his spare time for study, the farmer is rapidly becoming educated and learning each year better and better methods. In 1800 when practically everybody in America (ninety-seven per cent) lived on farms, the average wheat yield was only five and a half bushels per capita. Now, with only about one-third of our population living on farms, the average per capita yield is over ten bushels. If all farmers used improved implements the per capita yield would be still larger.

121. **The Advantages of Tillage.**—A great many of the advantages of tillage are already known to you, but let us bring these together and mention additional ones. Good tillage accomplishes the following things.

1. The soil particles are separated and broken and the soil made finer and deeper, so that the roots of the plant can penetrate more easily and the particles disintegrate and turn loose their food materials for the plant more rapidly.

2. It brings up new materials from below and turns vegetation and other matter under, in this way adding to the food material available for the crop.

3. When soil is cold and moist it aids the evaporation of water and the admission of air, which warms up the soil earlier in spring

4. It enables the soil to hold more water and more air.

5. During dry weather top cultivation conserves the water in the soil.

6. It prevents the growth of weeds that would rob the crop of food and moisture.

Just how tillage does all these things was made so plain in the chapter on the soil that there is no need to repeat it here. It is necessary only to add a few general principles of tillage.

122. **When to Plow.**—A large part of the labor of the crop should be done before planting. If roots are to have a bed that is easily penetrated, if there is to be a plentiful supply of water, air, and food material for the crop, the soil must be thoroughly broken before the crop is planted. As the freshly turned soil is full of large pores that interfere with the passage of capillary water in the soil, plowing should be done some time before the seeds are sown, in order to give the soil time to settle. When this cannot be done, the disk harrow and roller should follow the plow to press down the soil. If vegetation or manure is turned under, several weeks should be allowed for decomposition before seeds are planted. After all plowing the harrow should be used at once, as the clods are much more easily broken then, and water will be rapidly lost by evaporation if a mulch is not thus made on top of the soil. After all rolling the harrow should also follow in order to provide the needed mulch.

FIG. 74. This shows how the soil is loosened and the air is caught in it by plowing.

123. **Plowing the Subsoil.**—If any subsoil is to be turned up, this should usually be done in the fall, when it is drier than at other seasons, and when more time remains for

it to be acted upon by bacteria, humus, and air before the crop is planted. While it is wise to deepen gradually the top soil by turning up about an inch of subsoil each year, it is usually unwise to turn up two or three inches of hard subsoil at once, as it must be disintegrated and considerably changed before the plant can use it. When it is desirable to deepen the seed-bed at once in order that it may hold more water, or for other purposes, it is best to use a subsoil plow that breaks up the subsoil but does not bring it to the surface.

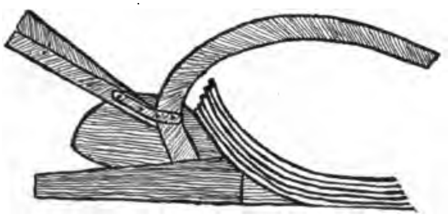


FIG. 75. The curve of the plow causes the layers of soil to slide by each other and thus separates the mass into smaller particles.

124. **When Too Wet or Too Dry to Plow.**—Plowing should never be done when the land is either too wet or too dry. Plowing land when too wet may injure it for many years. It is not easy to learn from a book how to tell when land is right for plowing. If it sticks together and the furrow slice shows a shiny, polished surface it is too wet. If it breaks into hard clods that do not easily pulverize it is too dry. Sandy land does not need to be so dry as other land when plowed.

125. **Soil Should Not Be Long Left Bare.**—It is usually unwise to plow up the soil and leave it long without a crop to cover it and prevent the loss of food materials to the air and through leaching.

126. **When and How to Cultivate.**—While each crop has its own peculiarities which one must know in order to

cultivate it properly, there are a few general principles that apply to all crops. All of these are easy to reason out now that we know what we do about the soil and about plant growth. Since it is through the tender root hairs in the new parts of the roots that food materials are taken in, then plainly we should not cultivate deep enough or near enough the plant to disturb these unless it is our purpose to stop the plant's growth. Since the valuable soil water is constantly coming up through the capillary tubes in the soil and being evaporated at the surface, and since a closely packed crust tends to increase evaporation and to retard the circulation of air in the soil, we should never allow this crust to form in our fields, but should plow after every rain, or as often as is necessary to keep the soil open and a dust mulch on the ground. If we have to plant a crop on soil that is wet or liable to get soaked, it is plain that we should first bed up the land and plant on the bed so that the roots of the young plants will not be drowned by the spring rains. On the other hand, if the soil is dry or liable to such drought as will dry out the moisture in the upper soil, we should list or

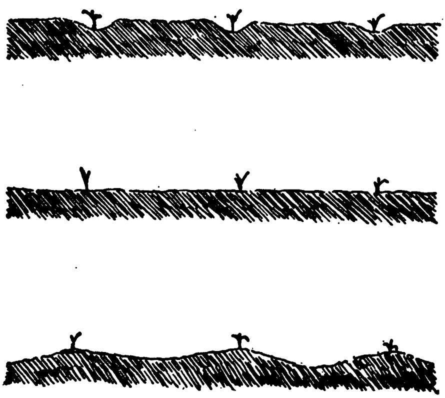


FIG. 76. In soil that is too wet or liable to become wet the crop is planted above the level of the ground; where the soil is dry or liable to become dry the crop is planted below the level of the ground. Can you see why this is done?

plant below the surface, so that the roots of the plants will be deep down in the moist soil. Since weeds and grass rob a soil of water and food materials that the crop should have, obviously we should always cultivate in time to prevent or kill while very young all grass and weeds. Other special

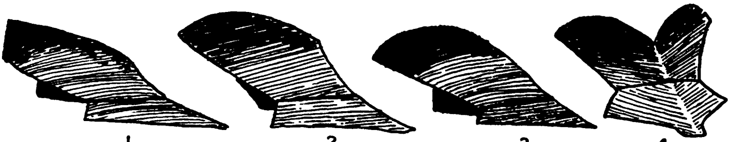


FIG. 77. Four types of plows: 1, a breaker. 2, a general-purpose plow for use in light land. 3, a black-land plow. 4, a middle burster.

directions with regard to tillage will be learned as we discuss the various farm implements and crops.

127. **Plows.**—There are two general classes of plows, the mould-board plow and the disk plow. The *mould-board plow* is the oldest type. With this the soil is cut by the *share* and turned upside down and broken by the curved *mould-board.* The amount of turning done depends upon the shape and size of the mould-board. If there is fresh sod to be broken and the land is heavy, the mould-board is usually less curved, as in this way the plow turns the soil over less and pulls easier. When the object is to turn materials under the soil the more curved mould-board is used. When it is desired to throw the soil out on both sides a still different type called a *middle burster* is used. All of these types are easily understood from Figure 77. The very interesting way in which the curved mould-board tears the soil apart and crumbles it by sliding the layers of soil on each other is well shown in Figure 75. *Disk plows* are shaped very differently from mould-board plows, the cutting and turning being done by

a circular instrument which rolls instead of sliding. For this reason they have some advantages in breaking sod and in plowing trashy land. They can be used also in soil that is too dry and hard or too sticky to be worked with a mould-board plow. The two types are about equally hard to

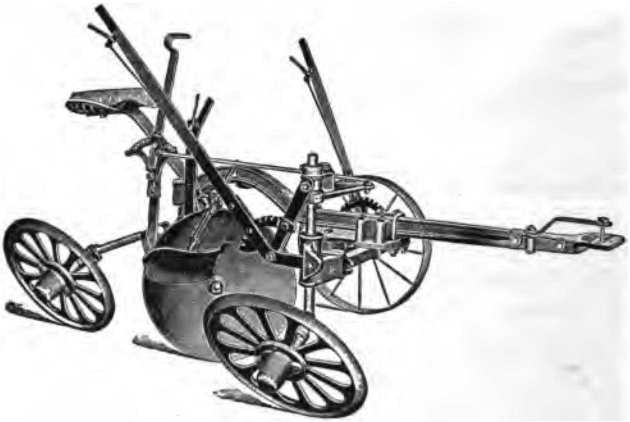


FIG. 78. Disk sulky plow.

pull under ordinary circumstances. Where fields are large and turns do not have to be made often, *sulky plows*, which are made in both mould-board and disk types, are usually to be preferred. If properly adjusted they pull as easily as do walking-plows, do somewhat better work, and yet allow the operator to ride.

128. **Harrows.**—The implements used for pulverizing the clods, smoothing the surface, and putting on a dust mulch are numerous and varied, each with its peculiar advantages and disadvantages. Where the broken land is rough and full of clods, or needs levelling and packing, the *disk harrow*

is especially valuable. This harrow may be set to cut from one inch to three inches. In loose sandy land it is not en-

Fig. 79. Disk harrow.

tirely satisfactory because of sinking so deeply into the soil. The *spring toothed harrow* has a number of strong curved

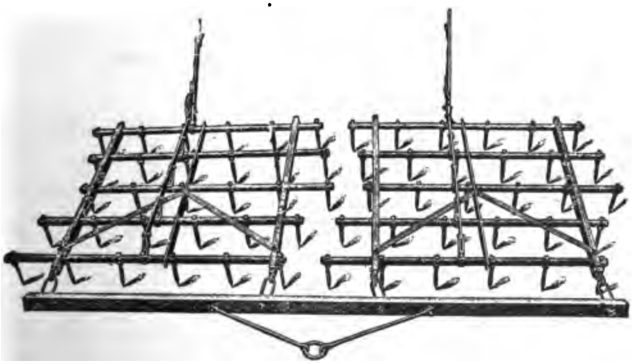


Fig. 80. Spike-tooth harrow.

steel springs, with teeth about two and one-half inches wide on the ends. These teeth are so arranged that they

FIG. 81. Acme harrow.

may be set to run two to three inches deep, thus breaking clods and fining the soil. The spring toothed harrow is often used immediately after the disk harrow to further work down a rough soil. If much vegetation has been turned under, this harrow is unsatisfactory, as the teeth pull much of it out of the soil again. When used after the disk harrow or on plowed soil that is in good condition, the *spike-tooth harrow* pulverizes and levels the surface soil very effectively. The *Acme harrow* is also especially valuable in pul-

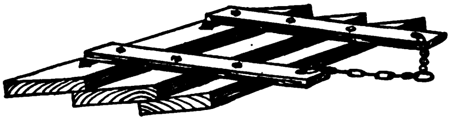


FIG. 82. Plank drag.

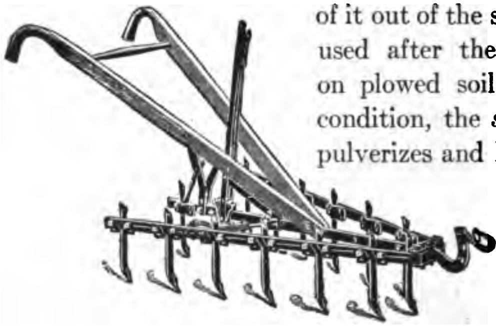


FIG. 83. Fourteen-tooth harrow.

verizing the surface, but is not satisfactory in stony soil or where heavy clods are to be broken. The *plank drag* serves very much the same purpose as the Acme harrow in smoothing and pulverizing the surface.

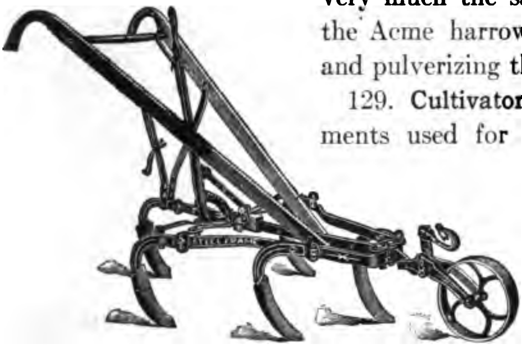


FIG. 84. Five-tooth harrow.

129. **Cultivators.**—The implements used for tilling the soil after the crop is planted in order to prevent weeds and keep the surface broken are called *cultivators*. The *spike-tooth cultivator* has a number (usually fourteen) of teeth about six inches long by one and one-half wide flattened

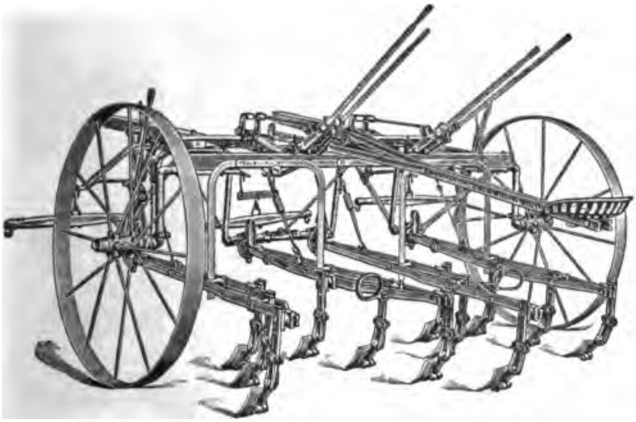


FIG. 85. Two-row sulky cultivator.

FIG. 86. Single corn and cotton planter.

somewhat at the end. These are run shallow and are especially valuable for breaking the crust and making a dust mulch. They do not destroy weeds as well as the other varieties of cultivator. The *five-toothed cultivator* has only five teeth, each from three to four inches wide. This cultivator destroys weeds better than the fourteen-toothed one,

FIG. 87. Double sulky corn and cotton planter.

FIG. 88. Manure spreader.

but pulls harder. It is widely used in potato and corn culture. The *diverse cultivator* has from six to ten long spring-like teeth, and does work similar to that done by other toothed cultivators. A constantly increasing part of crop cultivation, especially in broad, level fields, is being done with *riding-cultivators,* which do practically the same kind of work as do similar walking-cultivators. There are usually four or six shovels on a one-row cultivator. On a two-row cultivator this equipment is simply doubled. These cultivators have made it possible for one man to cultivate from

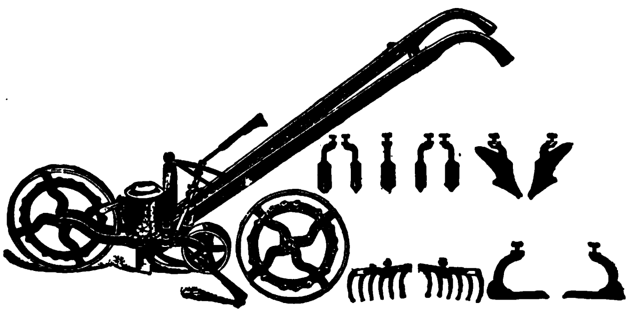


FIG. 89. Combination garden tool.

five to seven acres a day with a single-row cultivator and nearly double that amount with a double-row cultivator. When the double-row cultivator is to be used, the crop should be sown with a double-row planter, to make it certain that each pair of furrows runs parallel.

130. **Planters and Reapers.**—With a good planter one man can now not only plant as much in a day as eight or

Fig. 90. Corn shredder and silo filler in operation.
Courtesy of the International Harvester Co.

ten men can plant by hand, but he can do the work more uniformly and better. By this means a large crop can be got into the soil in a few days before a favorable season is gone. Some of these machines open the soil, plant the seeds, add the fertilizer, cover and roll two or three rows at a time. They can plant a continuous drill, as of wheat or oats, or

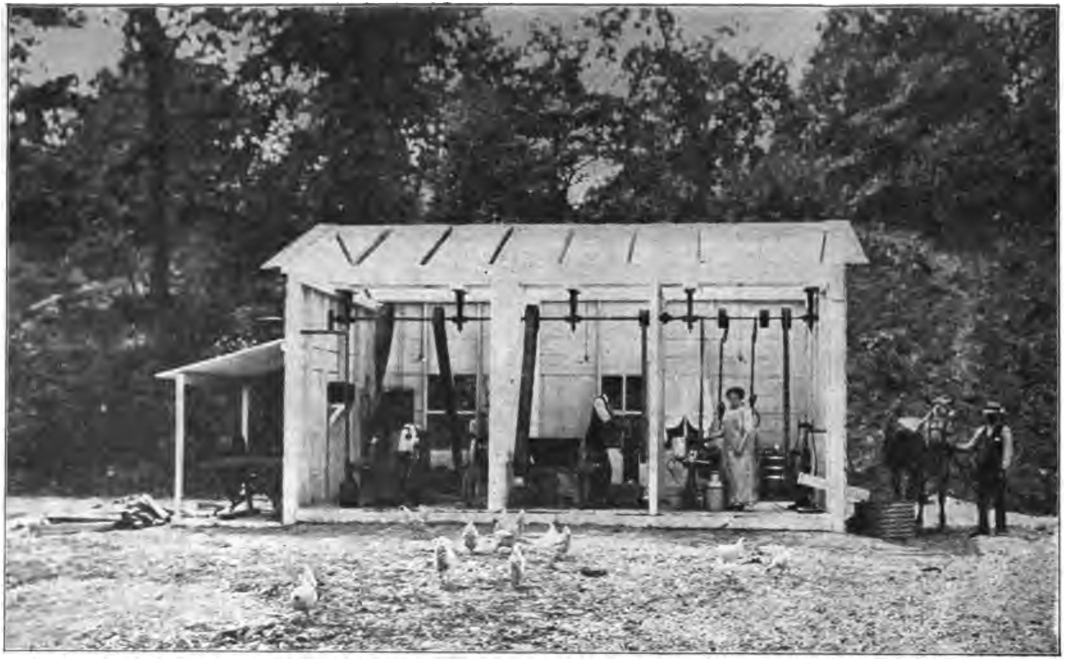


FIG. 91. Why should we do by hand what we can do more economically with an engine?
Courtesy of the International Harvester Co.

only at fixed intervals as may be desired. In the same way one machine now may do the work of many men in reaping the crop, thus not only lessening labor, but enabling the farmer to use short favorable seasons to advantage. We cannot go into the various types of planting and harvesting machines here, but shall mention one. You can learn about the others from the references at the end of the chapter. The *combined corn and cotton planter* is an implement that may be adjusted to plant either cotton or corn. The corn may be listed or planted level, and may be dropped at any distance apart that is desired. There are one-row and two-row types, the two-row type being especially desirable where it is intended later to use a two-row cultivator. Such a planter opens the furrow, selects the right number of grains from the seed-box, drops them into the right place, covers and rolls them. It may have also an attachment for distributing fertilizer at the same time.

131. **Manure and Fertilizer Distributors.**—Manure and fertilizer distributors bring about a saving of labor on the farm in the same way that planters do, and should be in more general use. Planters are frequently made with a fertilizer distributor attached. The handling of manure is a very important matter on the farm, which is usually done in a manner very wasteful of labor. The manure is handled once when thrown into a pile. Then it is thrown into a wagon. From the wagon it is thrown in piles on the field, then distributed from the piles. All this takes about twice the labor that should be used. By having the manure-shed conveniently located, and by distributing the manure directly from the wagon with a *manure spreader*, the labor is greatly lessened.

132. **Garden Tools.**—For work in gardens hand-power tools are now made with which the greater part of the work of the garden can be done with from one-half to one-tenth the labor required with the old-time tools. One such hand-power combination wheel tool is shown in Figure 89. With such a tool one can turn light soil, plant, distribute fertilizer, and cultivate with ease several times as much as with ordinary spades, hoes, and rakes.

133. **The Gasoline-Engine and Farm Machinery.**—Gasoline, gas, oil, and hot-air engines are now made that are not expensive, and are simple enough to be run by any intelligent boy. It should not be long before every thoughtful farmer has such an engine to pump water, churn, cut and grind feed, saw wood, fill silos, and in other ways economize labor.

134. **The Care of Machinery.**—It is to be regretted that so many farmers leave their implements in the field or elsewhere exposed to the weather. All tools and implements should be kept under cover protected from sun and rain. In this way they are not only in better condition for use when wanted, but they last much longer. The cost of a tool-shed will soon be repaid by the saving of the implements protected.

QUESTIONS, PROBLEMS, AND EXERCISES

84. What does tillage add directly to the soil?
85. Plow one acre in the fall, turning up one inch of subsoil, and plant a cover crop. Plow under the cover crop three weeks before planting in spring. Follow the plow with the disk and another harrow. On an adjoining acre with the same soil break the ground as usual in spring. Plant and cultivate both acres alike.

Repeat the treatment the next year, and compare the yield of the two acres for the two years.

86. Cultivate ten rows of corn with cultivators running not over two inches deep. With five of the rows make the final cultivation much deeper, plowing out the middles with a middle burster. Note the effect of each treatment on the yield of corn.
87. Leave five rows of corn in the field without the dust mulch. Keep the surface pulverized constantly on the other rows, cultivating after each rain, or as often as the surface packs together, and compare results.
88. The teacher should take the class to an implement store, and to neighboring farms, and carefully explain each implement. In cases in which the actual instrument cannot be seen, the picture should be shown.
89. Make a list of the instruments on your father's farm. State which are wasteful of labor. Make a list of such implements as it would be an economy for him to purchase.
90. If a sulky cultivator enables a man to do in one day with two horses as much as he could do before in five days with one horse, how much is this cultivator worth to him per year? First find the number of days per year that such cultivator is generally used, then find the cost of a single plow, man, and horse per day, and the same for a pair of horses in your neighborhood.
91. State all the advantages that would come to the South if satisfactory cotton-picking machines were in use.

REFERENCES FOR FURTHER READING

The books referred to in the chapter on soils contain discussions of tillage and implements.

CHAPTER VII

FARM CROPS

135. **Introductory.**—You have now learned the general principles that govern the nutrition, growth, and reproduction of plants, and the principles governing the cultivation of the soil and the conservation and increase of its fertility. These principles are universal; that is, they apply to all plants and all soils everywhere all the time. If some new plant that man had never cultivated were introduced, we should know that in cultivating it all these principles had to be observed: for instance, it would take its food materials through root hairs as do other plants, and it would manufacture its food out of the same elements. But, whether its roots would be deep or shallow, or in what proportion it took the different food elements from the soil, or whether the plant could stand drought or cold or shade, what was the best time to plant, the best method of cultivating and harvesting, and so on; all these we should not know. These special facts about each individual plant must be known before we can most wisely apply our general principles to the raising of that crop. If we have thoroughly mastered the important general principles, it will be easy to work out a wise plan of cultivation for any plant as soon as a few facts about its special characteristics and habits are learned.

To study the special characteristics and habits of all plants and apply to each of these the principles of growth and

cultivation would take several lifetimes. In this course we shall study just a few of the most important farm crops of our section, and shall tell you where you can find out about the others.

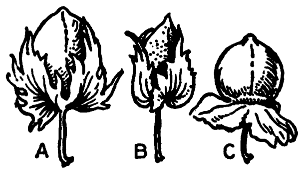
Cotton

136. **Cotton: Its Importance and Distribution.**—Cotton leads all other plants in the production of fibre. In many respects it is the most important plant on the globe. It furnishes the clothing for the larger portion of the world's inhabitants. The leading countries producing cotton are in order of importance: United States, British India, Egypt, Russia, China, Brazil, and Peru. The southern United States produces about two-thirds of the world's total supply of cotton, or from 11,000,000 to more than 15,000,000 bales per year. Of this amount Texas alone produces about one-fourth, or from 2,750,000 to 3,750,000 bales.

137. **Description.**—The wild cotton as now found in tropical countries is a perennial bush or tree reaching a height of fifteen or twenty feet. Cotton as grown in this country is an annual three to seven feet tall. It consists of a central solid woody stem called the *main stem.* From the joints of this main stem long ascending branches arise. These are called *primary branches.* Along the primary branches slender and shorter branches occur on which the bolls are attached. These slender branches are known as *fruiting limbs* because on these are borne the bolls. Often fruiting limbs are attached also to the main stem. The longest primary branches occur near the base of the main stem. These decrease in length toward the top of the stem, thus making the plant as a whole cone-shaped. In the

cluster types of cotton, there are only a few long branches near the base of the plant. Above these the fruiting limbs are attached directly to the main stem. The *boll* is a pod containing the seed and lint. There are from three to five divisions of each boll, the contents of each division being called a *lock*. The number of bolls on a single plant may vary from a few to several hundred, depending upon the variety, soil, fertility, rainfall, and climate. The cotton-plant under normal conditions develops a tap-root, which in a well-drained

Fig. 92. Cotton leaves: *A*, upland; *B*, sea island.



Cotton bolls: *A*, upland; *B*, sea island; *C*, Indian.

soil may go down to a depth of three or four feet. However, if the soil is not well drained, or if the subsoil is very compact, this tap-root may go no deeper than nine inches or a foot. The lateral roots or feeding roots branch from the tap-root at points from one and one-half to four inches below the surface of the soil. As the roots develop so near the surface of the soil, what kind of cultivation should be given cotton?

138. **Species.**—There are five species of cotton that are important in the world's agriculture. These are:

1. *American Upland Cotton.* This species represents the common cotton grown in the southern United States. It includes both the short staple and long staple upland cotton.

2. *Sea-Island Cotton.* This cotton grows chiefly on the islands and adjacent mainlands of South Carolina and

Georgia, though doubtless it would grow in other similar locations. It differs from the American upland cotton in having longer and more slender limbs, dark seeds free from

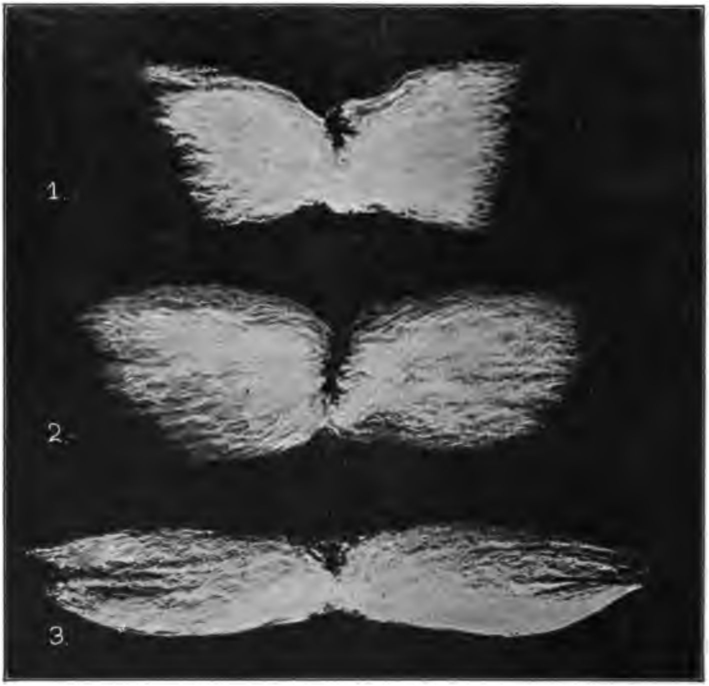


FIG. 93. Showing relative lengths of different varieties of cotton: 1, upland short staple; 2, upland long staple; 3, sea island.—*After Halligan.*

fuzz, longer and finer lint, and in yielding less per acre. On account of its long fibre, this brings a higher price per pound of lint.

3. *Peruvian Cotton.* This is the principal cotton of Egypt. It is somewhat closely related to American upland cotton.

4. *Indian Cotton.* This is cultivated largely in southern Asia. The lint is inferior to that of American cotton.

5. *Bengal Cotton.* This is also grown in India.

FIG. 94. Stalk 33 inches high; 102 bolls.
Courtesy of the N. C. Department of Agriculture.

Each of the above species contains a large number of varieties differing from each other as regards such characters as size of boll, shape of boll, length of lint, per cent of lint to seed, character of branching, climatic adaptation, soil adaptations, length of growing season, etc. A few of the most common varieties grown in the southern United States are Mebane, Triumph, Cook Improved, King, Peterkin, Simpkins, Russell, Toole, Allen Longstaple, and Rowden. Many fine new varieties are now being developed.

139. **Improvement of Cotton.**—The common practice of planting the ordinary grade of cotton-seed as it comes from the gin finally leads to an inferior grade of cotton, as well as

a decreased yield. Neither can one depend always on buying improved seed from some other locality, for a variety may be excellent on one kind of soil or under one kind of climatic condition and yet produce poor crops on a different soil or in a different climate. The first step in the improvement of cotton is to find by trial a good variety that is well adapted to the locality in which it is to be grown. The second step is to look carefully after the selection of seed each year. The following method is simple and practical.

Fig. 95. A good stalk of cotton.
Courtesy of the U. S. Department of Agriculture.

140. **Selecting Seed.**—At the second picking go through the field and pick into a bag the seed cotton from the best plants. This seed should be selected from plants possessing the following qualities:

1. *Productiveness,* determined by number of bolls per plant and size of bolls.
2. *Earliness,* indicated by a short-jointed type with basal limbs near the ground.

3. *Freedom from disease*, such as boll rot, rust, and cotton wilt.

4. *Character of the lint.* Plants bearing relatively short, coarse lint should be discarded.

5. *Storm-proof quality.* Bolls that open back too wide allow the cotton to drop out in a storm, and those that stand straight up do not shed water well.

FIG. 96. A poor stalk of cotton.
Courtesy of the U. S. Department of Agriculture.

This cotton picked from the best plants should be ginned separately, care being taken to see that the gin is first cleaned and that no mixing occurs at the gin. The selected seed is used for planting a seed patch, which should be large enough to furnish seed for the general crop the following year. Each year before the seed plot is picked, there should be enough seed selected from the best plants to plant the seed plot the next year. Maintaining in this way the seed plot every year, the selection continues and the cotton improves. No cotton farmer can afford to neglect the proper selection of his seed.

141. **Soil.**—Cotton will grow on almost any type of soil, from light sands to stiff clays, if it possesses fertility and is well drained. It usually grows best on clays or silty clays. In very sandy soils the plants have a tendency to rust. In rich moist bottom land cotton very often produces a very rank growth with a small number of bolls.

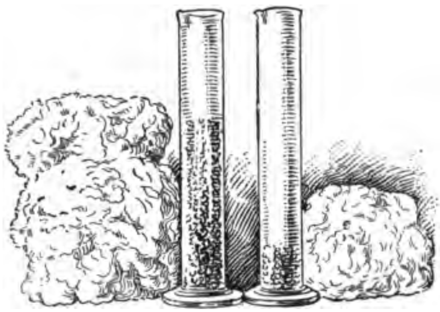


FIG. 97. Showing the yield of seed and lint from selected and unselected cotton-seed.
Redrawn from Bailey's "Encyclopedia of Agriculture."

142. **Rotations.**—The usual custom in the South has been the growing of cotton year after year on the same land. However, experience has demonstrated that higher yields can be produced when cotton is rotated with other crops. The reasons for this have been learned by studying the principles governing the rotation of crops. There is no one rotation for cotton that is best for all conditions. Each farmer must decide for himself the rotation which fits his type of soil, climatic conditions, and system of farming. A good rotation applying to Southern farms in general would be: First year, cotton. Second year, corn with cow-peas between the rows for seed. Third year, wheat or oats, followed by cow-peas for hay. If more corn or more cotton is desired, that crop can be grown two years in succession, making a four-year rotation.

In addition to the above-named crops the farmer should grow also when possible a winter cover crop of clover, vetch,

or small grain, to protect the soil from washing and leaching, and to add organic matter or nitrogen, or both, to the soil.

143. **Fertilizers.**—Cotton responds readily to fertilizers. The kind and amount of fertilizer to use depends on the character of the soil upon which the cotton is grown. Nitrogen and phosphorus are the elements most commonly needed. Potassium is present in most soils in sufficient amount. The most economical way to keep up the nitrogen supply in the soil is to grow the cotton in a rotation with leguminous crops, thus securing the nitrogen from the air. If it is not practicable to grow these legumes, nitrogen may be purchased in cotton-seed meal, nitrate of soda, dried blood, or tankage. In these materials the nitrogen costs about eighteen or twenty cents a pound. At this rate a crop of peas that would yield one to two tons of hay per acre will if turned under put from eight to seventeen dollars' worth of nitrogen in the soil besides the still more valuable humus. Phosphorus is bought in acid phosphate or bone phosphate, and is not nearly so expensive as the nitrogen. On average soils

FIG. 98. Field of cotton in Cherokee County, Texas, producing one and a half bales per acre. *Courtesy of "Farm and Ranch."*

three hundred to four hundred pounds of fertilizer per acre, made of equal parts of cotton-seed meal and acid phosphate, give good results. This is usually applied before or at the time of planting.

144. **Preparation of Soil for Planting.**—Land intended for cotton should be broken from six to eight inches deep, except in the case of extreme sands, where deep plowing is not needed, as the soil is already open enough. Care must be taken not to turn up too much subsoil at one time, as this new soil can give little food materials to the plant until it has been exposed to the air and moisture for some time. Where the previous plowing has been shallow it is best to plow an inch to an inch and a half deeper each year until the soil is of sufficient depth. Heavy clay soils are best plowed in the late fall or early winter. When plowed in the fall a cover crop should be planted to be turned under in the spring before the cotton is planted. This necessitates plowing twice, but it will result in much higher yields. Loams and sands may be planted to a cover crop in the fall without deep plowing, and these crops turned under in the spring in time for the soil to settle and become rather firm before the crop is planted. The best preparation for the planting is to plow the land broadcast, then ridges or beds are formed by throwing together at least four furrows. These beds are partially harrowed down and the cotton planted on top of the bed.

145. **Planting.**—Cotton may be planted by hand, but the planter is more commonly used. The seeds are put in much thicker than required for a stand. Planting is best begun as soon as the danger of frost is over. This is from the 15th of March in southern latitudes to the 15th

of May in northern. About one bushel of seed is planted per acre.

146. **Cultivating and Harvesting.**—Cotton should be cultivated as soon as practicable after the plants are up. This is best done with some form of fine-toothed cultivator, running as close to the plants as possible without covering them. To prevent the soil from being thrown on the young plants, a fender should be used. The cotton is then "chopped," or thinned, to the proper distance in the row by means of a hoe. This distance will depend upon the fertility of the soil, varying from twelve inches on poor land to twenty-four inches on rich land. The subsequent cultivations should be such as to keep down weeds and conserve moisture. Usually cotton should be cultivated every ten days. Deep cultivation should be avoided, as cotton has many shallow roots, and cultivating deeper than three inches destroys many of them.

Cotton is still harvested entirely by hand labor. Picking-machines that have been somewhat successful are now on the market, but these still are in the experimental stage.

Corn

147. **Corn: Its Importance and Distribution.**—Corn is a native of the New World. The early settlers found the Indians raising it when they landed in America, and learned from them its uses and how to cultivate it. Indeed, had it not been for this Indian corn many of the early settlers would have starved. The botanical name is *Zea mays*, and it is called *maize*, or *Indian corn*, to distinguish it from small grain, such as wheat and barley, all of which are called corn

by the people of Europe. The corn that we read about in the Bible was not Indian corn, but small grain.

The world's total production of corn varies from 3,000,000,000 to more than 3,500,000,000 bushels annually. Of this amount the United States produces more than 2,000,000,000 bushels, or over two-thirds of the total supply. Our corn crop of 1906 would fill a row of wagons stretching nine times around the world, each wagon holding 50 bushels and taking a space twenty feet long in the row. Corn is the most important crop grown in the United States. The acreage devoted to this crop is three times that of cotton and twice that occupied by wheat. The leading corn-producing States in the United States are Iowa, Illinois, Nebraska, Missouri, Kansas, Texas, Indiana, and Ohio. During the ten-year period from 1901–10 the average annual acreage of corn in Texas was 6,138,843 acres, producing 118,567,175 bushels, or 19½ bushels per acre. This is a low yield as compared with an average annual yield of 25 bushels for the entire United States, 35 bushels for Illinois, and 32 bushels for Iowa during the same period. Our low yield shows the necessity of more attention to our methods of corn production.

148. **Description.**—Corn is a member of the grass family. It differs from the other grasses in having the male and female flowers borne separately. The male flowers are borne in a spreading *panicle* (păn′ĭ-kl) at the top of the plant, known as the *tassel*. These male flowers on maturing produce an immense quantity of yellowish pollen grains. It is estimated that the tassel of each plant produces from 18,000,000 to 25,000,000 pollen grains. The female flowers from which the ears of corn develop are borne in the axils of

the leaves. The young ear is surrounded by a covering of shucks, which are modified leaves, and serve to protect the ear. Growing out beyond the shucks are the fine, slender, thread-like *silks*, which are the elongated styles and stigmas on which the pollen is caught as it is carried about by the wind. The pollen grain, lodging on the silk, begins to grow, sending out a long tube which grows down the entire length of the silk, until at the base it reaches the ovule. It thus unites with and fertilizes the ovule, and the grain of corn develops. Unless the pollen grains come in contact with the silks, no corn grains will be produced. There are as many silks as spaces for grains of corn on the ear. Only one pollen grain is required for each silk. The pollen may come from a tassel on the same plant or one on some other plant.

The corn-plant develops an extensive root system, a large part of which is shallow. There is no tap-root produced. The fine fibrous roots grow in a lateral direction and branch profusely. The greater portion of the feeding roots are found at a depth ranging from three to six inches below the surface of the soil, depending upon the character of the soil and the depth to which the seed-bed has been prepared. It has been noticed that a large number of the roots, after growing in a horizontal direction for one or two feet, turn down more or less abruptly, presumably in search of moisture.

149. **Races of Corn.**—There are at least six known races of corn. These are: 1, *dent corn;* 2, *flint corn;* 3, *sweet corn;* 4, *pop-corn;* 5, *soft corn;* and 6, *pod corn.*

The bulk of the American corn crop is dent corn. It is the common race of corn grown in the Southern States. and

is characterized by the presence of a small indentation, or dent, in the top of each grain. Varieties differ, but the usual tendency is to produce from one to two ears per stalk.

Flint corn is much harder than dent. The top of the grain is smooth or rounded, and the grains are shorter than

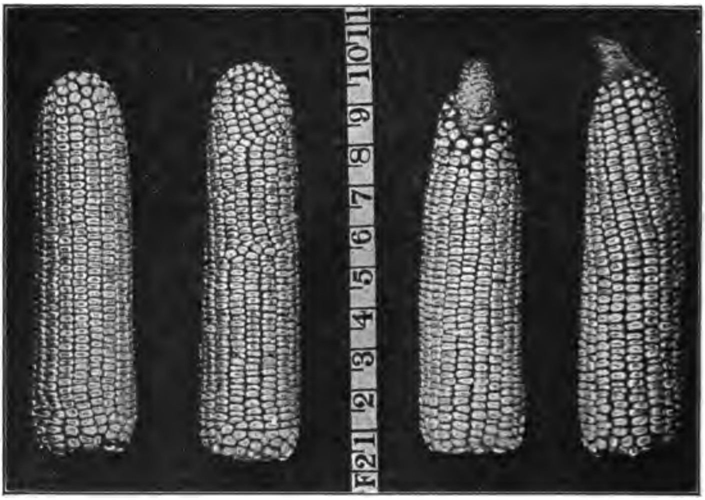


FIG. 99. Boone County white corn and the corn from which it was developed by selection.

Courtesy of U. S. Department of Agriculture.

those of dent corn. Plants vary in height from five to twelve feet, and have a tendency to produce two ears per stalk. Flint corn matures quickly, and is therefore grown near the northern limit of production.

Sweet corn presents a wrinkled, horny surface, and contains much more sugar than the other races. It matures early, the plants are small, and each plant bears a number of

small ears. In the South it is grown mainly in gardens and is highly prized for table purposes.

Pop-corn is characterized by its very small compact, horny grain. This compactness of the grain gives it its popping property. The plants are small, and several small ears are borne on each plant.

Soft corn bears a grain that is very soft and white. This corn was cultivated extensively by the Indians, because it is easily ground or crushed.

Pod corn is a curiosity and is not grown commercially. Each individual grain is inclosed in a small shuck, while the ear is covered by an outer shuck.

FIG. 100. These three stalks grew in the same hill. Differences in the seeds make the differences in the stalks.
Courtesy of Professor P. G. Holden.

150. **Varieties.**—Each of the above races of corn contains a large number of varieties that have been produced as the result of crossing, selection, or growth under different conditions of soil and climate. Some of the most commonly grown Southern dent varieties are Mosby, Hickory King, Marlboro, Cocke Prolific, Boone County White, Munson, Sure Cropper, Strawberry, Texas Gourd Seed, Bloody Butcher, and Mexican June

151. **Improvement of Corn.**—There are very few pure or uniform varieties of corn, due to the fact that it mixes so easily, because of the great distance to which the wind carries the pollen. Too little attention is given to improving our corn. Barren and poor stalks are allowed to ripen and pollenate good stalks, and selection of seed is usually made after the corn is in the crib. The result is that the variety deteriorates from year to year. It is entirely possible to increase the yield of corn from ten to twenty per cent by seed selection alone, an increase which comes with very little labor.

FIG. 101. These three ears grew on three different stalks in the same hill. Differences in the seeds make the differences in the yield. *Courtesy of Professor P. G. Holden.*

152. **Seed Selection.**—In selecting seed-corn the entire plant as well as the ear should be considered. This makes it impossible to make a wise selection of seed-corn from the crib, and necessitates selecting the seed in the field before the crop is harvested. A good plan is to go through the field at harvest-time and select seed ears from the most productive plants, at the same time taking into consideration such points as the position of the ear on the stalk, the height of the ear from the ground, and the general healthfulness of the plant. Much improvement will be secured if nothing more is

done than to select from productive plants enough seed to plant the next year's crop. However, even among ears that look equally good and come from equally good stalks, some will grow better and produce a great deal more corn than others. If the farmer wishes to have the very best seed, he

Fig. 102. The results of test of fifteen ears of corn. Ears 2, 6, and 9 are entirely dead; ears 3, 4, 7, and 8 are particularly vigorous.

Courtesy of Professor P. G. Holden.

must find out which of these good-looking ears are most vigorous and have the greatest producing power, and plant only from this stock. The vitality and growing power can to a great extent be determined by testing each ear in the germinator, taking six grains from different parts of the ear. Figure 102 shows the result of such a test. The difference in the producing power of different ears can be found out by what is called the ear-to-row test.

153. **Ear-to-Row Test.**—At least 25 of the best ears selected from the field should be planted on a uniform plot

of soil according to the following plan. Number the ears from 1 to 25 consecutively. Lay off 25 rows of equal length on soil of uniform productiveness. These rows should be at least long enough for 150 hills of corn. Plant row No. 1 from ear No. 1, row No. 2 from ear No. 2, and so on until the 25 rows have been planted from the 25 ears. All rows should contain an equal number of hills with an equal number of plants in the hill. The cultivation and general treatment should be the same for all rows. As soon as the tassels show and before any pollen has been shed, carefully pull the tassels out from one-half of every odd-numbered row, say the north half, and from the south half of every even-numbered row. This insures cross-fertilization, which has been shown to increase the production in corn. Seed should be saved only from the detasselled stalks, as the ears on these stalks were of necessity fertilized by the pollen from some other stalk or stalks. At harvest-time the ears from each row should be husked and weighed, keeping the ears from the detasselled stalks separate from those of stalks producing tassels. By weighing separately the corn from each row the best-yielding strain can easily be determined. Select the best ears from the detasselled portions of the eight or ten best rows for planting the general crop. If this does not furnish enough seed for the general crop, these selected ears may be planted on a half acre of good land and seed grown for the main crop. There should always be enough good ears selected from the best-yielding rows to plant a new ear-to-row plot the following year. All seed-corn should be hung in a well-ventilated place where it is not exposed to sudden changes of temperature or to attacks of mice or weevils.

154. **Results of Ear-to-Row Test.**—Ninety farmers in Iowa sent Professor Holden ears of their seed-corn to test

by the ear-to-row method. He tested them and found that the yield per acre from different ears varied all the way from 31.5 bushels to 80.5 bushels per acre. The six best producing ears averaged 77.5 bushels, and the six lowest 35.6 bushels, showing that by planting seed of the best-yielding

FIG. 103. Comparative yield of five highest and five lowest yielding ears at Story County, Iowa, station. The average of the five highest was 80.3 bushels per acre; of the five lowest 40.8 bushels. The seeds were all secured from seed corn being used as seed by the farmers. How much is Texas losing each year by planting inferior untested seed?

Courtesy of Professor P. G. Holden.

ears only the farmers would have added to their yield on the average 41.9 bushels per acre, or more than double what they would have made by planting the six poorest-yielding ears. Professor Holden also tested 102 ears of the selected seed-corn at the station, and these fine-looking ears varied in yielding power all the way from 90.5 bushels from ear No. 75 to 36 bushels from ear No. 93. Ear No. 19 gave 79 barren stalks, while ear No. 83 gave only 6; ear No. 54 had 258

broken stalks, while ear No. 85 had only 41. Not all of these qualities can be found out by testing in the germinator before planting, but the vitality and growing strength can be found out in this way. By testing in the germinator and throwing out all weak growing ears, and then by ear-to-row test discovering the other good and bad qualities, the farmer can now breed and improve his corn easily and rapidly.

155. **Soil.**—Corn will grow on a wide range of soil types. It makes its best yield on a deep, fertile, moist loam. A large per cent of the roots go down deep to supply the plant with water during dry periods. This necessitates deep preparation, especially if the soil contains considerable clay. Upland clay soils should be deepened gradually each year and at the same time vegetable matter added by the proper rotation of crops or by the addition of barn-yard manures. The seed-bed should be at least six inches deep, preferably eight. Bottom lands are better adapted to corn than upland soils, because they contain more moisture, but these must be well drained.

156. **Rotation.**—Corn is adapted to the same kind of rotation that was given for cotton. When both corn and cotton are included in the rotation, the corn usually follows the cotton, as it is often difficult to get the cotton crop off in time to sow a small grain crop.

157. **Fertilizers.**—Corn makes a very profitable use of rough manures containing organic matter, such as barn-yard manure or green manures. When the supply of organic matter is maintained by the above methods, nitrogen fertilizers need not be used. The same is generally true of potash, as the decaying vegetable matter will make sufficient potash soluble in the soil to supply the needs of the crop. Phos-

Fig. 104. The seeds from which these oat-plants grew looked very much alike, and were planted side by side. Which kind of seeds are you planting?
Courtesy of "Farm and Ranch."

phorus is usually more deficient in the soils than potash, and where the above system of maintaining the organic content of the soil is practised, phosphatic fertilizers will generally be found profitable for corn. If the soil is deficient in organic matter, then both nitrogenous and phosphatic fertilizers should be used. A common application of fertilizer for corn is four hundred pounds per acre, made up of two hundred pounds each of cotton-seed meal and acid phosphate.

158. **Planting.**—Much of the corn in the South is still planted by hand. Where possible the corn-planter should be used, as it insures a more uniform planting and germination, and also saves much labor. One-horse planters with fertilizer distributors are quite generally used, and are very satisfactory. The use of the two-horse check-row planter is restricted to level lands only. It is not generally used in the South, but where the conditions permit its use it may be very profitably employed.

159. **Time of Planting.**—Corn should be planted as soon as the soil becomes warm in the spring and the danger of frost is over. This varies from February 20 to April 15, depending upon the locality. If planted before the ground is warm, or while the soil is still too wet, corn is liable to rot before germination. Certain varieties of early corn, such as Mexican June, are often planted in June with good results.

160. **Depth of Planting.**—Corn is planted from one to four inches deep, depending on the soil and the season. It should be planted deep enough to insure the presence of enough moisture for good germination. On sandy lands deep-planting is generally the rule, while shallow-planting is

Fig. 105. The root system of corn.
Courtesy of Kansas Experiment Station.

better on wet clay soils. Early planted corn should not be covered as deeply as late-planted.

161. **Cultivation.**—Too often deep-tilling instruments are used in cultivation of corn. These large shovel plows pulverize the soil very ineffectively, and also destroy many of the feeding roots. Small-toothed cultivators or some form of sweeps make the most satisfactory implements for cultivating corn. These should not go deeper than from one and one-half to two and one-half inches, unless it be at the first cultivation on clay land that has a tendency to run together and bake.

162. **Harvesting.**—The usual custom of pulling the corn-blades for feed is expensive, and also decreases the yield of the grain. Cutting the tops just above the ears at the time when the outer shucks have turned brown is also unprofitable. This practice does not materially reduce the yield of grain, if done when the ears are fairly mature, but it is a very expensive way to get feed. The most profitable way to harvest the corn crop is to cut and shock the whole plant. This should be done when practically all of the shucks have turned brown and the grain has become hard. This practice does not decrease the yield of grain. In this way all the forage is saved, and the use of the land is obtained for fall cover crops. In some localities the corn thus harvested is run through the shredder, which shucks and separates the ears from the stalk, at the same time tearing the stalk to pieces. The shredded leaves and stalks are known as *stover* (stō′ver), and are readily eaten by stock.

163. **Corn-Judging.**—How to judge corn will be treated when *corn clubs* are discussed in Appendix V.

The Forage Sorghums

164. **Groups of Sorghums.**—There are three distinct groups of cultivated sorghums: 1, those varieties grown for syrup, owing to the high sugar content of their juices; 2, those grown for their tops, or flower stalks, which are used in making brooms; 3, those grown for forage and grain, such as the Kafirs and durras. The last group is the most important, and our study will be restricted to these.

FIG. 106. Heads of milo maize and Kafir corn from near Dalworth, Texas.
Courtesy of "Farm and Ranch."

165. **Kafir and Durra.**—There are three commonly known varieties of Kafir, distinguished more especially by the color of their seed and hulls. These varieties are *red*, *white*, and *black-hull*. The red and black-hull varieties generally yield a little more grain than white Kafir, and are considered more desirable. They also grow taller than white Kafir, thus producing a little more forage. The chief varieties of durra are: *yellow milo*, *brown durra*, and *white durra*, or *Jerusalem corn*. Milo is grown more extensively than either of the other varieties,

especially in western Oklahoma and the Panhandle of Texas. It matures in a shorter time than Kafir, and is

Fig. 107. Field of milo maize near San Benito, Texas.
Courtesy of "Farm and Ranch."

especially valuable for arid and semi-arid regions. The grain of this variety is large, brittle, and easily masticated by stock. Brown durra is grown extensively in certain sections of the country, especially in California, where it is

often called "Egyptian corn." As the grain shatters easily, it is not considered as valuable as yellow milo. White durra is not grown extensively in this country. Owing to its liability to injury by insects and fungus diseases, and to the fact that the seed shatters easily, it is not a very satisfactory crop.

Kafirs and durras are especially adapted to semi-arid regions, owing to their drought-resisting properties, and should usually be depended on for grain rather than corn. They vary from four to eight feet in height.

166. **Soil.**—These crops are best adapted to a good clay or loam soil. They make a fair growth even on a poor soil, but of course do best on a soil of high fertility.

167. **Preparation of Soil and Seeding.**—The seed-bed is prepared in very much the same way as for corn. Where the crop is grown for grain, plowing is often done in the late winter or very early spring, so that the land will hold more moisture and the seed-bed get firm before planting season. The land should be thoroughly pulverized and the seed planted in drills three and one-half to four feet apart, and three to five, and in very poor land eight, inches apart in the drills. It is planted best with a corn-planter with a drilling attachment. In regions of little rainfall, listing is a very common practice. This is done by throwing out furrows at planting time with a lister, the seed being drilled in the bottom of these furrows. This insures deeper rooting and better enables the plants to withstand drought.

168. **Cultivation.**—The cultivation of these crops is the same as for corn. The sorghums are shallow rooted, a fact which necessitates shallow cultivation. Small-toothed cultivators are generally used.

169. **Harvesting.**—If grown primarily for grain, the crops should not be harvested until the seeds are fairly mature. The entire stalks may then be cut with a corn-harvester and shocked like ordinary corn, or the heads may be first cut off with a knife or header and the stalks afterward harvested for stover. The heads should not be stored in large piles until they are thoroughly dry, as they heat easily. The grain may be threshed by running the heads through an ordinary grain thresher, or, if the entire plant has been cut, the heads may be inserted into the thresher until the seeds are removed, the stalks being then withdrawn. While much higher yields can be produced, the usual yield varies from twenty to forty bushels per acre.

Legumes, or Nitrogen-gathering Plants

170. **What Legumes Are.**—By legume is meant that class of plants the members of which bear their seeds in pods, and increase the supply of nitrogen in the soil because of certain bacteria which live on their roots and have the power of taking in the insoluble nitrogen from the air and working it into the soluble nitrogen compounds called nitrates, on which plants can feed. The common representatives of this group are cow-peas, soy-beans, pea-nuts, the clovers, vetches, and alfalfa. These are especially valuable plants to agriculture, because they improve the soil as well as produce the best of foodstuffs and forage.

171. **Tubercles.**—If one will carefully examine the roots of cow-peas, clover, or any of these legumes, he will find a large number of small galls, knots, or nodules growing on them. These galls are known as tubercles. They are pro-

duced by bacteria that live on the roots of the plant. Each tubercle contains thousands of these bacteria, which are alive and must have food. Part of this food they get from

Fig. 108. Red clover in both pots; no nitrogen in soil of either, but bacteria in the pot on the right. *Courtesy of the University of Illinois Agricultural Experiment Station.*

the plant on which they grow and part of it from the air which circulates through the soil. The food that these bacteria get from the air is pure nitrogen, which makes up four-fifths of the air. This insoluble nitrogen unites with other elements in the bacteria and makes a soluble nitrogen compound. The bacteria finally die and the legume takes the nitrate left by the bacteria and uses it in its growth. Finally when the legume dies and decomposes, the nitrogen which

was taken out of the air by the bacteria is left in the soil for the use of other plants.

172. **Inoculation for Legumes.**—The bacteria that produce tubercles on clover are different from those that grow

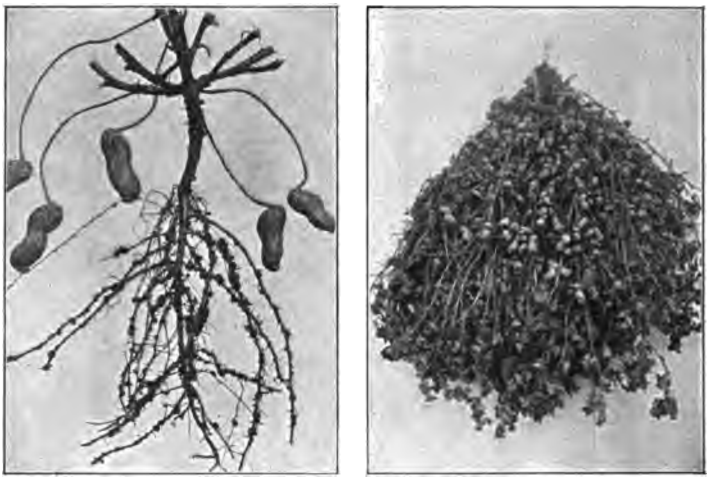


Fig. 109. Pea-nut plant from the Panhandle.
Cut on the left, courtesy of the United States Department of Agriculture; on the right, courtesy of "Farm and Ranch."

on alfalfa. In fact nearly all the different kinds of legumes have their own particular bacteria, and if the right kind of bacteria is not in the soil, it must be added before the legume can be grown successfully. This addition to the soil of material containing the proper bacteria is called *inoculation* (ĭn-ŏc-ū-lā′shŭn). The best way to inoculate a field is to add to it soil that contains the proper bacteria. For example, if one wished to inoculate an acre of land for alfalfa, he would apply to it about two hundred and fifty pounds of soil from a field that was growing alfalfa successfully. This would

FIG. 110. Gathering and stacking pea-nuts.
Courtesy of "Farm and Ranch."

be sprinkled on as would a fertilizer and harrowed into the land. Inoculation does not have to be repeated every year, as the bacteria live from year to year in the soil. All legumes do not need inoculation. For example, the bacteria that grow on the roots of cow-peas are present in nearly all soils and would not have to be added.

We shall speak of only a few of the most common legumes.

173. **Pea-nuts.**—The pea-nut plant is an annual, growing from one to two feet high, depending upon the variety grown and the soil. The fruit, or seed, which is not a nut at all, is borne in pods underneath the surface of the soil, on tips of stems. These stems start out from the axils of leaves above ground and, after blooming, push their way into the soil and there develop the seed.

174. **Varieties.**—Two well-defined types of pea-nuts are recognized: those with large pods and those producing small pods. A common representative of the former group is the Virginia pea-nut, used for roasting. The Spanish pea-nut is the small-podded variety. These are used mostly for making confectionery and feeding hogs.

175. **Soil and Fertilizers.**—The pea-nut does best on a loam soil containing plenty of lime and not too much humus. If barn-yard manure is used, it should be applied to the preceding crop, so as to give it ample time to decompose thoroughly before the nuts are planted. Nitrogenous fertilizers are seldom applied, as the pea-nut can secure its own nitrogen from the air. Potassic and phosphatic fertilizers are largely used.

176. **Planting and Cultivation.**—The land should be plowed and prepared as for corn, but with even greater care. The large-podded pea-nuts are usually planted about

Fig. 111. **Cow-peas in corn rows in Johnson County, Texas.**
Courtesy of Texas Experiment Station.

the time corn is planted, while the Spanish pea-nuts may be planted considerably later, at any date from the time that cotton comes up until about July 1. The small-podded pea-nuts, which usually produce an erect growth, are generally planted in rows about twenty-four to thirty inches apart, and from four to eight inches apart in the row. For the large-podded varieties the rows should be from thirty to thirty-six inches apart. A weeder should be run over the land after the pea-nuts are planted and before they have come up. After the plants are up, a fine-toothed cultivator should be used, and cultivation should be frequent, keeping the soil finely pulverized, so that the plants will have no difficulty in producing the pods. One or two hoeings are usually necessary, depending upon the abundance of weeds.

177. **Harvesting.**—Pea-nuts intended for seed or market should be harvested before frost. A common method of harvesting is to run under the row on each side with a turn plow from which the mould-board has been removed. This plow should be run at sufficient depth not to tear the pods from the branches. The plants are then lifted by hand or with a fork and stacked, usually on the same day that they are dug. The plants should be stacked with the tops turned outward and the stacks made as slender as possible. They are capped with grass or straw.

178. **Cow-peas.**—The cow-pea is the most important Southern legume. It is grown on the widest variety of soil of any Southern hay crop. It fits into almost any system of crop rotation that the farmer wishes to practise, and is valuable either as hay, pasture, or seed crop. A crop of cow-peas may be grown after small grain comes off in the

spring, before small grain is seeded in the fall, or between two crops of small grain. They are generally grown as a secondary crop, being sown at the last cultivation of corn, except in regions of very dry summers, where they must be sown earlier. They may be either pastured off, used for

FIG. 112. Field of cow-peas.
Courtesy of "Farm and Ranch."

seed production or for hay. They are often planted in drills between the corn rows, or between the hills of corn in the same row. In either case they are allowed to mature and the seed is harvested. Twenty bushels per acre is a good average yield. Cow-peas should never be planted until the soil gets thoroughly warm. Deep preparation of the soil is not essential to the successful growth of cow-peas, though on heavy clay soil it is very profitably employed. When sown

broadcast, from one to one and one-half bushels of seed per acre are required. When sown in drills, one peck of seed is usually enough. Acid phosphate makes up the bulk of the fertilizer used, although considerable amounts of kainit are under certain conditions desirable. No nitrogen fertilizer is

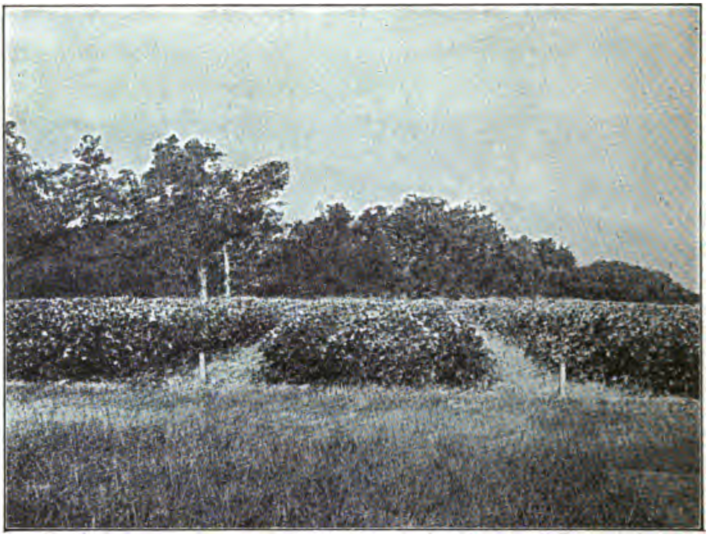


FIG. 113. **Soy-bean field. A good legume for hay and for building up the soil.** *From Halligan's Fundamentals of Agriculture. Courtesy of Messrs. D. C. Heath & Co.*

necessary. Cow-peas should be harvested for hay when the most mature pods are beginning to turn yellow. One and one-half tons of hay per acre is a good average yield. The *soy-bean* is rapidly coming into favor in some parts of the South-west. It possesses advantages in some respects over the cow-pea for certain localities. These should be studied carefully in the bulletins and tested on every farm.

179. **Alfalfa.**—Alfalfa is grown primarily for hay, but is sometimes used for pasture, soiling, or silage. Owing to the large amount of palatable hay produced, together with the fact that this hay contains a high percentage of protein, there is no more valuable forage plant in sections where it can be readily grown.

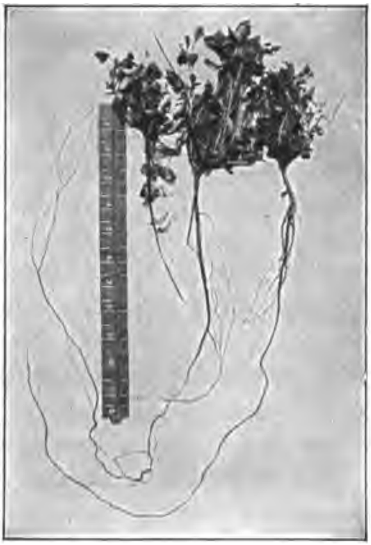


FIG. 114. An alfalfa-plant only a few months old. The roots are three feet long. Under very favorable conditions alfalfa roots are known to have run over forty feet.

180. **Description.**—A single plant of alfalfa ordinarily produces from five to twenty-five erect stems growing out from a single crown. These stems range in height from eighteen to thirty (sometimes sixty) inches, depending upon the soil upon which it is grown. Plants growing alone may produce from one hundred and fifty to two hundred stems. The arrangement of the leaves is somewhat different from that of true clover, the lateral leaflets being borne on the side of each leaf stalk instead of at the end, as in the clovers. The stems are rather slender, making a hay of excellent quality. The seeds are borne in a much-twisted seed-pod having when mature a corkscrew appearance. Alfalfa produces a very deep-growing tap-root. These roots have been known to grow to a depth of forty-five feet. On ordinary soil the usual depth is probably from five to ten feet, depend-

ing upon the character of the subsoil and the distance of standing water from the surface of the soil. Under suitable conditions the root tubercles begin to form about two or three months after sowing.

181. **Alfalfa Regions in Texas.**—Alfalfa may be successfully grown on the black prairie and Fort Worth prairie soils of central and northern Texas when it escapes root rot, to which it is very subject. The river bottom soils of east Texas when well drained are also adapted to alfalfa-growing. In recent years alfalfa has been successfully grown on certain areas of the "red-bed" soils in north-west Texas, although the deficient rainfall in this section makes it very necessary for the alfalfa farmer to put forth every effort for conserving soil moisture, such as early plowing to enable the soil to store up easily the rainfall, and the maintenance of a loose mulch until planting to prevent loss of water by evaporation. Considerable alfalfa is grown under irrigation in the arid sections of south-west Texas.

182. **Essentials to Success in Alfalfa-Growing.**—The following are essential to successful alfalfa-growing: 1. The soil must be well drained to a depth of three or four feet. Alfalfa is a deep-rooted plant, and the presence of surplus or standing water in the upper three or four feet of soil is detrimental to its growth. 2. The soil must be fertile. Alfalfa should not be sown on land that does not possess fertility enough to produce two-thirds of a bale of cotton or thirty-five or forty bushels of corn per acre. 3. The soil must contain a rather large amount of lime. Alfalfa gets its nitrogen from the air as a result of the growth of tubercle-forming bacteria on its roots. These bacteria will not thrive in an acid soil. The soil must be alkaline, and if sufficient

lime is not naturally present, from one thousand to one thousand five hundred pounds of slaked lime per acre should be applied and incorporated with the soil at least two weeks before the seeds are planted. 4. The bacteria that grow on the roots and form the nodules must be present. As a rule, when alfalfa is grown for the first time in a locality, the soil should be inoculated. This is best done by the method outlined in paragraph 172. 5. The soil must have deep and thorough preparation. Weeds and grass will easily kill out alfalfa, hence the preparation of the seed-bed should be such as to get rid of weed seeds. 6. Good seed must be planted. Alfalfa seeds are often put on the market in a low state of vitality, and the farmer should always test the germinating power of the seeds before they are planted. 7. There must be sufficient moisture in the soil when the crop is planted to germinate the seeds. Failure very often results from sowing alfalfa during a dry season when there is little moisture in the soil. Fall sowing is generally better than spring sowing, as in this way the young plants get the start on the weeds in spring; but unless a suitable season can be obtained in the fall it is better to wait and seed in the spring.

183. **Amount of Seed to Sow.**—Most farmers sow too little seed. Twenty or twenty-five pounds per acre should be sown. Alfalfa does not spread by root stocks or *stool out,* like wheat or oats, and unless sufficient seed is sown a good stand need not be expected.

184. **Time of Cutting.**—Alfalfa should be cut when the second growth is just starting. By examining the base of the plants the farmer can easily tell when the second growth of young stems is being put out from the crown. This is the time for cutting. This is usually when the crop is about

one-tenth in bloom. If cutting is delayed until the second growth is far enough advanced to be clipped by the mower, the yield of the succeeding cutting will be greatly lessened.

185. **Curing the Hay.**—Alfalfa hay should not be left in the swath exposed to the sun for more than two or three hours. Many farmers put it in small cocks immediately upon cutting. The cocks should be small and carefully made so as to shed rain. The curing process will go on favorably under these conditions, while at the same time the leaves do not become so dry as to shatter when the hay is handled. If mould should occur, the cocks may be opened up for a short time. In arid regions, immediately after cutting, the hay is raked into windrows eighteen to twenty-five inches deep and is cured in the windrow. The hay is hauled directly to the stack from the windrow, often by means of "buck rakes." Any method of curing, to be successful, must be such as to avoid the loss of the leaves, as these are the most nutritious portion of the plant.

Good alfalfa gives from three to six cuttings a year, yielding from three and one-half to four and one-half tons of hay per acre. Where it is irrigated and the growing season is long, more cuttings and heavier yields are obtained.

186. **The Clovers.**—To this group of plants belong *red clover*, *white clover*, *crimson clover*, *alsike clover*, and *mammoth clover*. These are known as the true clovers. Japan clover (lespedeza, lĕs-pé-dē′zȧ) and bur-clover, while commonly classed as clovers, are not in any way related to the above plants, and are not true clovers. Bur-clover is closely related to alfalfa. The true clovers most commonly grown in the South are the crimson, red, and white. Crimson clover is an annual, and therefore has to be seeded every

year. It is seeded in the fall and will produce a crop of hay in time for corn to be planted on the land the next summer. About twenty pounds of seed per acre are sown. Red clover is a perennial. It is primarily a hay plant, but is sometimes used for pasture. It grows best on fertile land containing considerable lime. In the South it is best sown in the fall at the rate of ten or twelve pounds of seed per acre. White clover is primarily a pasture plant, and is seldom grown for hay, owing to its prostrate, or creeping, habit of growth. It is usually sown in mixtures of grass-seed for pasture at the rate of from two to six pounds of seed per acre. Bur-clover is an annual, but reseeds itself readily. It makes its growth in the late fall and early spring, and hence is a good supplement to pasture grass mixtures, giving good grazing at a season of the year when the grasses are dead. Japan clover is an annual, making its growth during the summer months. It is used primarily for pasture, but some hay is produced from it. Japan clover often covers waste land that has been abandoned because of its poverty, greatly aiding in restoring this land to productiveness. Its value is too little appreciated by Southern farmers.

Sugar-Cane

187. **Sugar-Cane: Its Importance.**—Sugar-cane is a coarse grass grown in tropical and semi-tropical countries for its stems, the juice of which is used for the making of sugar and syrup. It differs from ordinary sorghum (commonly called cane) in containing a higher percentage of sugar in its juices, and also in not producing seed in this country, and only sparingly in tropical countries. Sorghum produces an abundance

of seed in a compact panicle at the top of the plant. The sugar-cane is used primarily for sugar-making, while sorghum is used for making molasses. The plants of sugar-cane vary in height from eight to fifteen feet. The stems are usually close-jointed and very leafy. Sugar-cane was probably the first plant used in the manufacture of sugar. It is still one of the most important crops for this purpose, notwithstanding the great increase in the culture of other sugar-yielding plants within recent years.

188. **Roots.**—As a usual thing sugar-cane does not produce a prominent tap-root. A number of the finer roots, however, go deep into the soil, thus enabling the plant to secure moisture. The roots of sugar-cane do not branch as profusely as do the roots of corn. From the lower nodes, or joints, of the plant roots also come out above the ground, go down into the soil, and serve to brace and nourish the plant.

189. **Varieties.**—No satisfactory classification of the varieties of sugar-cane has as yet been made. The most generally used classification is that which is based upon the color of the stalk. Three classes are recognized: 1, the *green and yellow group,* in which the stalks are uniformly green and yellow; 2, the *red group,* in which the stalks are of a reddish color; 3, the *striped group.*

190. **Sugar-Cane Regions.**—The important sugar-cane regions in the United States are found in southern Louisiana and southern and eastern Texas. In Louisiana cane is grown from New Orleans to within about one hundred miles of the Texas line. In Texas it is grown in the lower Brazos and Colorado bottoms, in creek valleys in east Texas, and in the lower Rio Grande Valley.

191. **Soil.**—Sugar-cane requires a well-drained, deep, sweet soil. Owing to the large amount of water which is passed through the plants during their growth, the soil must have a high water-holding capacity. Almost any fertile soil in the sugar-cane belt supplying the above conditions can be profitably used for this crop. In plowing the land for cane, steam-plows are often used, breaking the soil in some sections as deep as eighteen to twenty inches. All soils cannot be plowed to this depth, as the subsoil is often of such a nature as to make it inadvisable to bring very much of it to the surface. However, deep plowing must be the rule for sugar-cane.

192. **Fertilizers.**—The best fertilizer for sugar-cane is stable manure. This is seldom produced in sufficient quantity to supply the needs of the crop, and the use of artificial fertilizers is resorted to. The usual custom in disposing of the crop is to extract the juice, burn the remainder of the crop, and return the ashes to the soil. This aids in maintaining the supply of phosphorus and potassium, but it results in the loss of organic matter and nitrogen. As a result the most commonly purchased ingredient for cane fertilizer is nitrogen. A soluble fertilizer, such as nitrate of soda, is usually applied to the surface of the soil after the crop has made a portion of its growth, and is worked into the soil by cultivation. The less soluble materials, such as dried blood, tankage, and fish refuse, should be added earlier and mixed rather deeply with the soil. On acid soils lime is very beneficial.

193. **Planting.**—In this country sugar-cane does not produce seed. In tropical countries some varieties produce a small amount of seed, while others do not produce any.

The seed produced is inferior, and has a very weak germinating power. Plants produced from seed grow very slowly, requiring several years to attain full size. For the above reason sugar-cane is propagated by planting the stripped stalks, or from cuttings made from stalks. The buds, or eyes, located at the joints of the cane grow and produce plants. A very common method is to plant the entire uncut stalk. The land is first thrown up into high beds, with drainage furrows between. These beds are from four and one-half to seven feet wide. A furrow is opened in the top of each bed with a double mould-board plow, and a double row of cane is planted in the bottom of the furrow. With this method about four tons of cane are required to plant an acre. Planting is best done in the fall, although some cane is planted in February and March. Another common practice is to plant the cane in hills. In this case there are three common methods applicable:

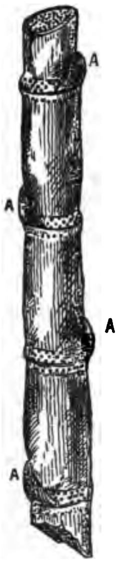


FIG. 115. Stem of sugar-cane, showing the "eyes" at the joints from which the plants grow.

1. Laying the "seed-cuttings" horizontally in the row, with the eyes, or buds, facing laterally.

2. Placing the cuttings on a slant of about forty degrees, with the upper end protruding from the soil.

3. Placing the cuttings vertically in the soil, with the upper end of the cutting protruding.

These cuttings are spoken of as "seed-cane." This "seed-cane" is usually covered only an inch and a half to two inches deep, especially in irrigated regions.

194. **Culture.**—During the first few months after planting, the cane is actively cultivated, usually with a one-horse cultivator. The object of this cultivation is to keep down

FIG. 116. **Field of sugar-cane at La Feria, Texas.**
Courtesy of "Farm and Ranch."

weeds and stimulate the growth of the cane. Shallow cultivating is much preferable to deep cultivation.

195. **Harvesting.**—The cane must be harvested before frost. However, the longer the cane can be allowed to grow in the fall the higher the percentage of sugar. The crop is harvested by hand, no successful harvester having as yet been invented. Immediately after the cane is cut, it is taken to the mill and ground. If the grinding is delayed more than twenty-four hours after cutting, fermentation begins and the quality of the juice is injured.

196. **Yield.**—Twenty to twenty-five tons of cane per acre is a fair yield. Often more than this is produced. A ton of cane yields from one hundred and fifty to one hundred and sixty pounds of sugar. This gives more than three thousand pounds of sugar per acre. As much as four thousand five hundred pounds of sugar per acre have been produced.

Rice

197. **Rice and Its Distribution.**—Rice is an annual belonging to the grass family. It is grown for its grain, which is borne in a spreading panicle somewhat resembling that of oats. This grain is more widely used as a food material than any other cereal. It forms the principal article of diet for more than one-half of the world's inhabitants. Asia produces more rice than any other continent. Next to Asia comes Europe, followed by North America. The leading rice-producing States in the United States are Louisiana, Texas, Arkansas, South Carolina, and Georgia, producing a total of from twenty to twenty-five million bushels of rough rice. Of this amount, Louisiana produces about twelve million bushels and Texas about ten million bushels.

198. **Types and Varieties.**—There are two types of rice grown in this country. These are upland rice and lowland rice. The upland rice is grown on relatively dry soils without irrigation. The lowland rice is the more important type. There are few varieties of rice grown in the United States. In the Eastern States white rice and gold seed rice are grown in considerable quantities. In Louisiana and Texas the most important varieties are Honduras and Japan rice. The Honduras rice produces a rather large grain, and is not

so easily blown down because of the stiff straw produced. The Japan rice produces a short thick grain, and the plants do not grow as tall as Honduras rice. It is said to yield more grain than Honduras.

FIG. 117. Types of rice. On the left Honduras rice, on the right Japanese rice.
From Halligan's "Fundamentals of Agriculture."

199. **Rice Soils in Texas and Louisiana.**—The rapid development of the rice industry in Texas and Louisiana has been due to the opening up of large areas of prairie land in south-east Texas and south-west Louisiana. These rich drift soils have shown a remarkable adaptation to rice. They have heavy clay subsoil, and for that reason are very retentive of moisture, and, being practically level, are especially adapted to irrigation. They are sufficiently far from the coast to be free from storms and the attacks of birds.

200. **Preparing the Ground.**—Rice land is usually plowed in the spring. The better the soil is pulverized the greater

is the yield. Deep plowing is more satisfactory than shallow plowing, although rice does best in a rather compact soil. This compact condition can easily be produced by the use of a heavy roller after the land has been plowed. The plow should be followed in a short time by the disk harrow and then by the smoothing harrow.

201. **Sowing.**—Rice should usually be sown from March 17 to April 20 for best results. Drilling rather than broadcast sowing is preferred, as a more uniform stand can be attained. Broadcast sowing is still very common, but this practice should be discarded. One to two bushels per acre is sown.

202. **Germination.**—Very often the seed germinates poorly because of too little moisture in the soil. Some farmers let on enough water to saturate the ground immediately after sowing, drawing off at once any surplus water. A few sprout the seeds before planting by placing bags of rice in water. However, if the soil is dry when these germinated seeds are sown, failure is sure to follow.

203. **Irrigation.**—Rice is best produced on land which can be kept flooded from the time the plants are six to eight inches high until near the time of maturing. Therefore land must be chosen that has some convenient supply of water for irrigation, has a retentive subsoil, and is practically level. In Louisiana and Texas the water used for irrigation is pumped from bayous and rivers, or from underground wells. By means of pumps and a system of canals the water is brought to the highest part of the fields. Low levees, or embankments, are constructed throughout the fields, chiefly with the plow, so that the water can be maintained at a uniform depth through the different portions of the field.

This depth should be from three to six inches. The water is applied when the plants are about eight inches high, and a constant circulation of the water is maintained by a continuous inflow at the highest portion of the field and an outflow at the lowest portion. The water should all be drawn off in time for the soil to get firm before harvest-time, as this allows the use of improved machinery in harvesting the crop. The irrigation takes the place of cultivation in keeping down the weeds.

204. **Harvesting.**—Where the water can be drained off the land, rice is best harvested with the self-binder. It is first put up in shocks in the field and capped in such a way as to shelter the heads from sun and rain. It remains in the shock until the straw is cured and the grain is hard. Threshing is done in the same manner as with other grains.

QUESTIONS, PROBLEMS, AND EXERCISES

92. Bring in a cotton-plant and point out the main stem, primary limbs, and fruiting limbs.
93. Examine five cotton-bolls, each from a different stalk, and make a record of the number of locks in each boll, number of seeds in each lock, and any points in which the bolls differ.
94. Find three different varieties of cotton in your neighborhood and describe each.
95. Dig carefully around a cotton-stalk standing in the field and see what effect would be produced by cultivation two inches, three inches, four inches, and five inches deep.
96. Select the best stalk of cotton in your father's field. Gather the cotton, pick the seeds by hand, and plant these away from all other cotton. Cut out all poor stalks before they bloom, save seeds of the one best stalk again, and pick by hand and plant as before. Use the seeds of the other stalks to plant a large seed patch, and continue this selection for five years in accordance with the system shown in the diagram on the next page.

97. Select six of the best stalks in your father's field, and enough of the poorest stalks to furnish a quantity of cotton when gathered equal to that obtained from the six best stalks. When ready to plant, take an equal quantity of the ordinary gin-run seed planted on the farm and plant side by side, in separate rows, first, the mixed gin-run seeds; second, the seeds from the selected plants; third, the seeds from the very poor plants. Cultivate all alike, and keep a record of the amount produced by each variety of seeds. Then calculate how much cotton would have been produced on the entire farm by planting altogether from each kind of seed.

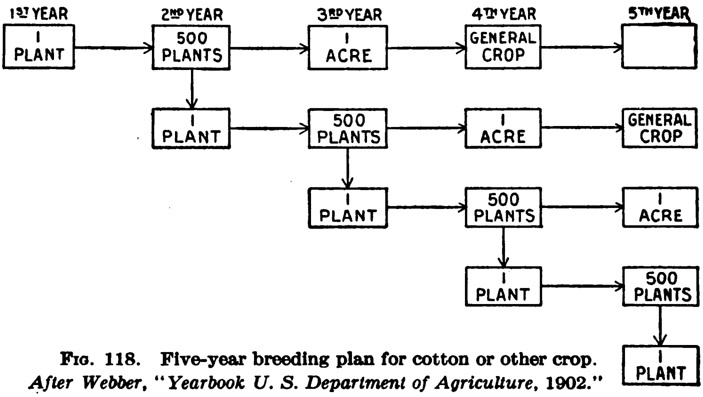


Fig. 118. Five-year breeding plan for cotton or other crop. *After Webber, "Yearbook U. S. Department of Agriculture,* 1902."

98. Draw and label the parts of an actual corn-plant.
99. Bring in corn-shucks which show that shucks are modified leaves.
100. Dig down in the row of a growing corn-field, and make note of how the feeding roots are distributed.
101. Plant corn one, two, three, and four inches deep. After four weeks, dig up the plants and note the character of each, especially the character of the roots, and tell which is the best depth to plant on that soil.
102. Plant rows of corn from grains taken from tips and butts, and parallel to these plant rows from the middle parts of the same ears. Keep a record of results.
103. Select the five best ears in your father's corn-field, and next year plant the seed in an ear-to-row test, far away from all other corn;

cut out all poor stalks before they develop any pollen, and detassel alternate halves of each row. Save the cross-fertilized corn from the detasselled stalks separately for seed.

104. When the corn in the experiment above is gathered, calculate how much corn your father would have raised if all his seed-corn had been as productive as the best ear of this lot.
105. Select the best five ears from the detasselled stalks in experiment six, and the best five ears from the other stalks. Plant these side by side, cultivate exactly alike, and note how much each produces.
106. Select fifty ears of your father's seed-corn and test for germinating power.
107. In a section where there is a fair supply of winter rain, and some rain during spring and early summer, but long drought during June, July, and August, what qualities must a grain have in order to be successfully cultivated?
108. Collect and describe as many varieties of Kafir and durra as you can find in your community.
109. Make a selection of especially fine stalks of either Kafir or durra growing on your farm, and breed up a finer variety by the same methods given for corn and cotton.
110. Find plants of Japan and bur clover. Draw and describe each and bring the plants to school.
111. Examine the roots of each kind of legume in your neighborhood, find the tubercles, and make notes of the different characteristics of each, drawing them.
112. Select seed from especially fine plants of peas or other legumes and breed an improved variety.
113. Get your father to help you make the following experiment: Plant peas in the rows of half the corn in one field. Also sow rescue-grass and bur-clover seed, about fifteen pounds per acre, at the last cultivation of this same half. Gather the peas for seed and graze the clover and grass till the spring plowing, when all sod is turned under. Plant cotton, or corn and peas, again on both halves of this field. Keep account of cost of seed and labor, and of value of all crops raised on each half of the field, and of the value of the grazing. Find out whether the legumes and grass paid, and if so, how much. (A great deal of the value of the legumes and green manure is still in the soil after the first year, and will add to whatever crop is grown on the land for several years.)

114. Sow one acre of peas broadcast. Sow another one in rows and cultivate. Keep account of cost of seed and labor, and find out which pays best.
115. In a very dry climate, would it be better to plant peas broadcast or to plant them in rows and cultivate? Why do you think so?
116. Plant test rows of six varieties of peas and two varieties of soy-beans on your corn land. Give all equally good land and the same cultivation, and see which is best suited to your needs. Try this in a dry season and in a wet season.
117. Make a drawing of a complete rice-plant, if this crop grows in your neighborhood.
118. An acre of land contains 43,560 square feet. A gallon of water contains 231 cubic inches. How many gallons of water does it take to flood an acre field one inch deep? How many to flood it one foot deep? How many six inches deep?
119. Select the best five rice-plants in your field, plant fifty seeds from each of these, one foot apart, in rows one foot wide the next year. Plant these five rows on the edge of the rice-field from which the wind usually blows. Watch the plants, weigh the grain from each fine plant, and again select the best. Plant these seeds next year and keep this up till you have bred up a variety that will uniformly give large yield.

REFERENCES FOR FURTHER READING

Books treating a large number of crops of the variety indicated by their titles.

"Field Crops for the Cotton Belt," J. O. Morgan.
"Southern Field Crops," J. F. Duggar.
"Forage Plants and Their Culture," C. V. Piper.
"Forage and Fibre Crops in America," T. F. Hunt.
"The Small Grains," M. A. Carleton.
"Clovers and How to Grow Them," Thomas Shaw.

Alfalfa.
"The Book of Alfalfa," F. D. Coburn.
Farmers' Bulletins, nos. 339, 636, 757, 865, 944, 982, 1021, 1185, 1229.

Beans.

Farmers' Bulletin, no. 289. "Beans."
Farmers' Bulletin, no. 962. "Velvet Beans."
Farmers' Bulletin, no. 973. "The Soy Bean."
Farmers' Bulletin, no. 1275. "Bean and Pea Weevils."
Texas A. and M. College Farm and Home Hints on Soy Beans and Velvet Beans.

Clovers.

Farmers' Bulletin, no. 455. "Red Clover."
Farmers' Bulletin, nos. 579, 646, 1142, on crimson clover.
Farmers' Bulletin, no. 693. "Bur Clover."
Farmers' Bulletin, nos. 797, 820, 836, 1005, on sweet clover.
Farmers' Bulletin, no. 1151. "Alsike Clover."
Farmers' Bulletin, no. 1143. "Lespedeza as a Forage Crop."

Corn.

Farmers' Bulletins, nos. 537, 773, 992, 1149, 1175, on growing corn.
Farmers' Bulletins, nos. 739, 872, 875, 891, 915, 950, 1025, 1029, 1046, 1124, 1176, on insects and diseases of corn.
Texas Experiment Station Bulletin, no. 276, "Corn Variety Experiments," and no. 270, "Black and Yellow Moulds of Ear Corn."

Cotton.

Burkett and Poe, "Cotton."
Farmers' Bulletins, nos. 501, 1098, 1262, on the cotton boll weevil.
Farmers' Bulletins, nos. 555, 831, 890, 1187, on insects and diseases attacking cotton.

Cow-peas.

Farmers' Bulletin, no. 1148. "Cow-peas: Culture and Varieties."
Farmers' Bulletin, no. 1153. "Cow-peas: Utilization."
A. and M. College of Texas Bulletin, "Peas and Peanuts."

Oats.

Farmers' Bulletin, no. 420. "Oats: Distribution and Uses."
Farmers' Bulletin, no. 436. "Winter Oats for the South."
Farmers' Bulletin, no. 892. "Spring Oat Production."
Farmers' Bulletin, no. 1119. "Fall Sown Oats."

Pea-nuts.

Farmers' Bulletin, no. 1127. "Pea-nut Growing for Profit."

Potatoes.

Farmers' Bulletins, nos. 533, 868, 1064, 1190, 1205, 1225, on growing Irish potatoes.

Farmers' Bulletins, nos. 970, 999, 1020, 1059, on growing and storing sweet potatoes.

Rice.

Farmers' Bulletin, no. 673. "Irrigation Practice in Rice Growing."

Farmers' Bulletin, no. 1086. "Insects Affecting the Rice Crop."

Rye.

Farmers' Bulletins, nos. 756, 894, on culture of rye.

Sorghums.

Farmers' Bulletins, nos. 477, 724, 827, 965, 972, 973, 1137, 1147, 1158, on production and uses of various sorghums.

Texas Experiment Station Bulletins, nos. 195, 204, 236, 261, 269, 275, 279, 285, 294, on several varieties of sorghums, their cultivation and feeding values.

Vetch.

Farmers' Bulletin, no. 515. "Vetches."

Wheat.

Farmers' Bulletin, no. 885. "Wheat Growing in the Southeastern States."

Farmers' Bulletins, nos. 1006, 1041, 1058, 1083, 1213, 1224, 1226, on insect pests and diseases of wheat.

CHAPTER VIII

THE GARDEN

205. **Home-Gardening Differs From Truck-Growing.**—Raising a home vegetable garden is quite different from trucking, or raising vegetables in large quantities for the market. Trucking is practicable only where the soil and climate are favorable and the transportation and marketing of the produce are easy. In trucking large fields and special equipment for tillage and marketing should be used. In the home garden the aim is to furnish the family a supply of fresh wholesome food at all seasons and add an attractive feature to farm living. The surprises and delights in growing the variety of plants found in a garden are many. Only a few farmers can profitably be truck-growers, but every farmer should have a good home garden. The growing of truck is very important in Texas, but in an elementary work treatment of this must be omitted and the space given to the more generally needed home garden.

206. **Value of the Garden.**—The farmer probably gets a larger return from the time, money, and land devoted to a vegetable garden than from any other expenditure on the farm, provided it is intelligently managed. At the University of Illinois a careful account was kept of a half-acre vegetable garden for five years. During that time the garden produced an average of one hundred and five dollars' worth of vegetables per year at a cost for seeds, labor, and in-

secticides of thirty dollars per year. A vegetable garden is valuable not merely because it produces foodstuff worth so much money, but also because it furnishes at all seasons of the year the fresh green foods that are necessary for the best health and working efficiency. Meat, bread, molasses, and dried vegetables all the time do not give an economical or wholesome ration. The human system needs for its best development the fresh foods with phosphates and acid juices in them, just as the plant needs phosphates. With a properly planned garden and suitable berry bushes, grape-vines, nut and fruit trees, all of which take only an acre or so, the farmer has over half his food supply at practically no cost, and has it fresher and better than it could be bought at any price.

207. **Location and Soil.**—For the average family a half acre will furnish an abundance of vegetables all the year. The garden should be near the house for convenience in caring for and gathering the vegetables. A well-drained spot somewhat protected from the high winds should be chosen. The soil should be a sandy loam or clayey loam. Coarse sand or heavy clay makes a poor garden soil. If such must be used, the character should be improved at once by the addition of manure, green manure, well-rotted chips, leaf mould, ashes, lime, sand, or whatever is needed to make a loose, rich, finely pulverized soil. The soil must be given humus enough and be broken deep enough to hold moisture well. When practicable, the garden should be located where it can be irrigated from the tank. Often a very small amount of water will save a vegetable crop. The garden spot should be thoroughly broken and ten to twenty-five loads of stable manure turned under in the fall in time to allow for decom-

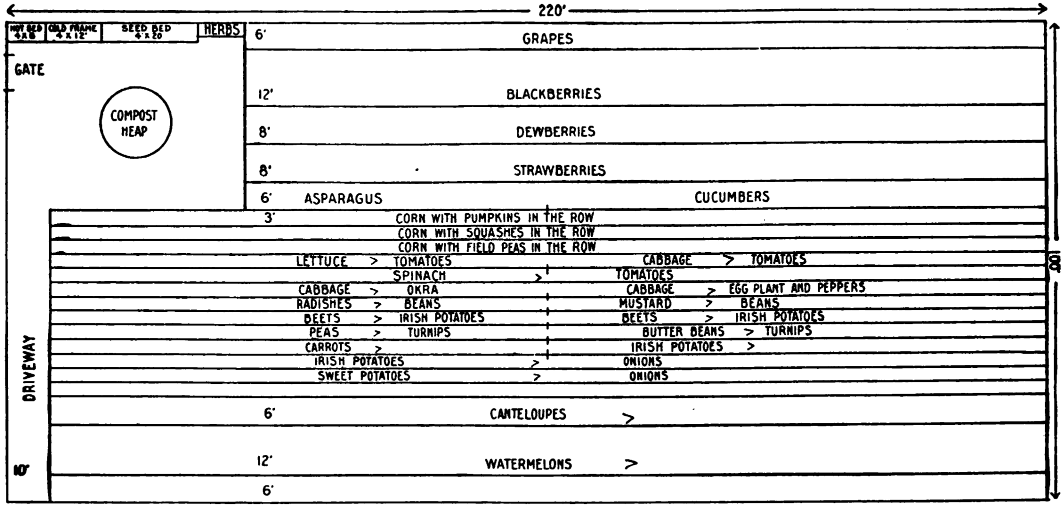


FIG. 119. Plan for a half-acre garden that is easy to cultivate. Lettuce > tomatoes means that tomatoes are planted after the lettuce is harvested.

position. Before the seeds are sown the soil should be plowed and replowed, disked, harrowed, and dragged until it is thoroughly pulverized, settled down, and the surface levelled and covered with a fine mulch.

208. **Shape and Arrangement.**—The garden should have a wide gate to admit wagon and team, should be oblong, so that the rows may be long, and should be so planted that the tillage can be done largely with teams. The rows should extend the entire length of the plat, and should not be less than thirty inches apart for the use of the horse cultivator, and fifteen inches for the hand wheel cultivator. Small square patches worked by hand make gardening needlessly burdensome and expensive. The grape-vines and berries are usually planted on one side of the vegetable garden, the grapes in rows about twelve feet apart, and the berries in six or eight foot rows. Blackberries and dewberries should be in every garden in the Southwest, and in almost every section some of the numerous varieties of bunch grapes, especially hybrids created by crossing the Eastern grapes on our native wild ones. Valuable arbor grapes produced by the same crossing are now on the market. Where no other grape can be planted a few of the wild grapes for making jelly, jam, and grape juice should be placed where they may be easily gathered. Occasionally a few of the vegetables which cannot

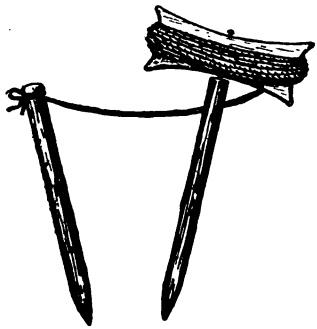


FIG. 120. A home-made garden reel.
Courtesy of the U. S. Department of Agriculture.

stand the hot sun may be grown under the arbors. Mint and parsley beds should be planted somewhere in the garden or yard near a water supply, as they need frequent watering. While these have no food value in themselves, it has been proved that attractive decoration and appetizing flavors given to foods tend to increase their digestibility.

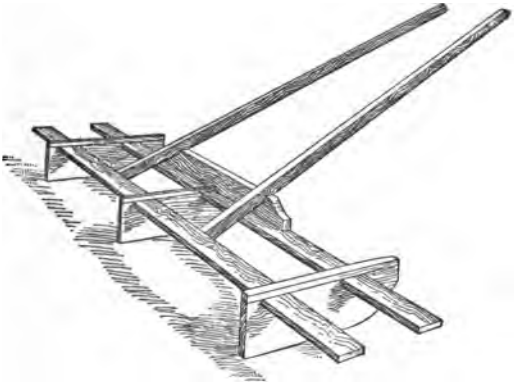


FIG. 121. A home-made sled marker.
Courtesy of the University of Illinois.

209. **Garden to Furnish Fresh Food at all Seasons.**—A well-managed garden should furnish food at all seasons of the year. The same season varies in character from year to year and, of course, there are great differences in the climates of the Gulf Coast and the Panhandle, so that no statement would fit all sections; but a few general suggestions will help to guide the beginner. In the climate of Austin, as early as January, one may plant the hardy vegetables that a light frost will not kill, such as turnips, radishes, lettuce, spinach, mustard, cabbage, onions, carrots, beets, and garden peas. Occasionally a very cold spell will kill some of these, and they will have to be replanted. In case they escape there will be radishes and greens in February, and a plentiful supply of vegetables in March and April. All of these may be planted

again in February when Irish potatoes are planted. Tomato, sweet-pepper, and egg-plant seeds should now be planted in boxes in the house or in a hot-bed. In March the same vegetables that are planted in February may be planted again, except the turnips, carrots, spinach, and lettuce, which are not usually profitable after the warm weather sets in. The early varieties of cabbage may be set out now, or even earlier, but these usually do better when grown in fall and winter. Okra, beans, and field peas also may well be planted in March. In April okra, beans, field peas, butter-beans, squash, pumpkins, corn, watermelons, cantaloupes, and cucumbers should be planted. The tomato, pepper, egg-plant, and sweet-potato slips should now be set out. In May okra and late corn may again be planted, and more tomato-plants be set out. An early and late variety of each of the above vegetables should be planted, and string beans and corn should be planted about every three weeks to give a succession of crops. The above should give an abundance of vegetables from March to August. Tomatoes, okra, potatoes, and pumpkins should run on till frost. If tomatoes are picked late in the season when full-sized, but still green, they may be wrapped in paper and stored in a dark cellar, kept until frost, brought out, and ripened when wanted. Tomatoes, butter-beans, peas, beans, okra, pumpkins, and corn should be canned and kept for use at all seasons. Butter-beans, peas, beans, and okra should be dried. Tomatoes, pumpkins, and Irish and sweet potatoes should be stored.

The fall garden may be begun in August if there is a favorable season. Now the winter-growing vegetables, such as cabbage, lettuce, spinach, beets, turnips, salsify, and winter radishes, should be planted. The roots of asparagus and the

berries may now be set out. If the season is unfavorable in August the same vegetables should be planted in September, with Bermuda onions and shallots. In many sections all these vegetables make good crops when planted in October. They will furnish fresh green food all winter and into the early spring.

Some crops should be growing on all parts of the garden at all seasons of the year. As the growing season of many

FIG. 122. A horse cultivator for garden use.

vegetables is only a few months, it is possible to secure two or three crops each year from the same land, if ample manure and fertilizer are added.

210. **Cultivation.**—Wherever water can be secured for irrigation the crops are of course made more certain and the vegetables more tender. It is useless to plant most vegetables unless the soil is very fertile and well supplied with moisture. Good tillage and repeated additions of humus and fertilizing material make a good garden possible even in dry sections

and without irrigation. At times it is necessary in addition to the dust mulch to cover the soil with a mulch of leaves, chopped straw, hay, or other material that will hold in the moisture.

The methods of planting and cultivating each vegetable are easily learned from the directions on the seed packages

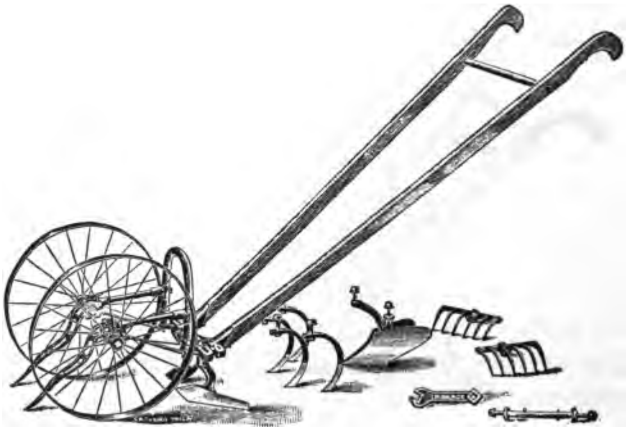


FIG. 123. An inexpensive wheel hoe for cultivation of the garden.

and from the references given at the end of this chapter. The general principles of plant growth, tillage, and fertilization which you have learned will enable you to apply or to modify intelligently these directions to meet your needs. In planting, the seeds should usually be covered to a depth about equal to three or four times their own thickness. The soil should be pressed down closely upon them either by rolling or tramping, and then loose soil raked over the packed soil to hold the moisture. The soil must be kept constantly stirred and no weeds allowed to grow and scatter their seeds.

All fence rows and corners should be kept clean even in winter months, to prevent as far as possible the harboring of insects. By planting in long rows after some such plan as is shown in Figure 119, it is possible to do nearly all garden cultivation with the horse cultivators. Where rows are too narrow for this, the type of wheel hoe shown in Figure 123 does excellent work with far less labor than when hand hoes and forks are used.

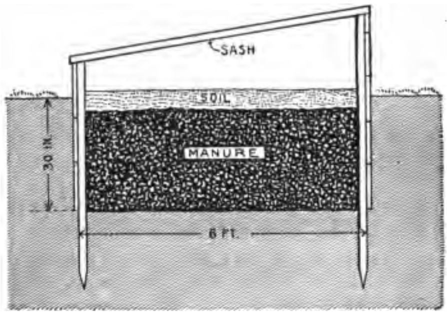


FIG. 124. A hot-bed.

211. **Hot-Beds and Cold-Frames.**—In order to have very early vegetables it is often best to plant during cold weather in the house in boxes, or in a specially prepared bed and frame out of doors. Figure 124 illustrates a convenient form of out-door arrangement, called a *hot-bed.* A hole is dug about a foot deep and as large as the hot-bed is to be or larger. This is filled with damp horse manure that is beginning to heat. On this the wooden frame is set. About six inches of good garden soil is placed inside the frame and soil is piled up outside all around the base. The decomposition going on in the manure serves to keep the soil warm. Such frames may be of any size. They should be from eighteen to twenty-four inches deep on one side, sloping down to twelve or eighteen inches on the opposite side. As they must be covered with sash, it is well to have a shape that some cheap stock size of sash will fit. Three by six and four by eight feet

Fig. 125. Tomato-plants ready for setting in the field. Note the large amount of soil carried with the roots.

are convenient sizes. They should be narrow enough to enable one to reach across easily. Where manure is not used and no bottom heat is provided, such a frame is called a cold-frame. At times these are covered with cloth instead of glass. The hot-bed and cold-frame offer protection not only against cold but to some extent against insect pests. Plants that are started in such frames are tender and must be gradually hardened by first raising and later taking off the covering on mild days, thus by degrees exposing the plants to the weather. Any one can make a hot-bed, and the expense is so small that every family can have one.

Fig. 126. Handy box for use in seeding or when plants are transplanted while in hot-bed in order to increase their size.

212. **Transplanting.**—You have learned that in transplanting the delicate root hairs are usually torn from the roots as they are taken from the soil,

and because of this the plant is unable to make any headway after being transplanted until new root hairs are developed. In many cases the plant never recovers. This injury may be largely avoided by planting the seeds in small pots or cans and transplanting the plant and soil together. A similar result can be secured by planting in a shallow box like that shown in Figure 126. By fastening one side of this box with screws or nailing it lightly so that it may be easily removed, it is possible to cut around the plant with a trowel and remove it and the soil together, so that the roots and root hairs are undisturbed. Frequently the plants are transplanted once in the hot-bed while very small, being reset about four inches apart. When this is done they grow more vigorously, and a larger mass of soil and root can be taken up with each plant when it is carried to the garden. Transplanting is best done on damp days or late in the afternoon. If the soil is not thoroughly moist, water should be poured into the hole and the loose soil drawn in and lightly pressed upon the roots. After this, more loose soil should be drawn around the plant over the wet spot to hold in the moisture. It is important when transplanting to trim carefully all bruised roots and to take off an amount of the top to correspond to the amount of the root lost. Unless the soil and plant are moved together, with the roots left undisturbed, the roots should be care-

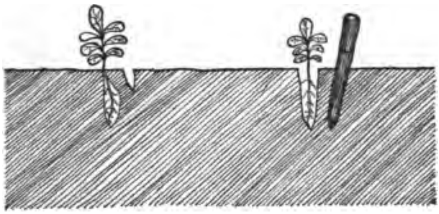


FIG. 127. The right and the wrong way to set out plants with a dibber.

fully spread out before being covered with soil. Figures 127 and 128 show clearly the right and wrong ways to transplant.

213. **Watering Plants.**—Plants should not be watered while the sun is shining on them. The water should be put on late in the afternoon or early enough in the morning to

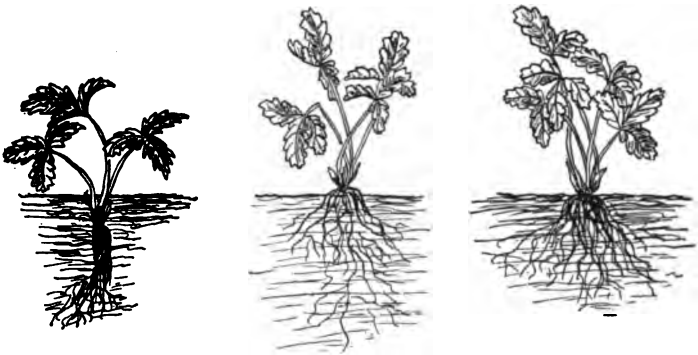


FIG. 128. Transplanting. The roots of the plant on the left will never grow well. The plant in the centre is set too high. The one on the right is correctly planted.

soak in well before the sun gets hot. Frequent shallow waterings are not as good as occasional thorough soakings of the soil, because in surface wetting most of the water is lost by evaporation, and the growth of a very shallow root system is encouraged. After the water has gone down and the surface begun to dry, the crust should be broken or covered with a mulch before the water has time to come to the surface and be evaporated. When water is poured around individual plants or run down a trench, the wet places should be covered with dry soil as soon as the water has soaked in.

214. **Saving Seeds.**—Seeds imported from the North have the advantage of maturing somewhat earlier than home-grown seeds, and those bought from a reliable seed house are less apt to be mixed than are those grown at home. On a great seed-breeding farm each crop is planted widely removed from all that might cause a mixture. Although home-grown seeds may not be quite so early in maturing, and may be somewhat mixed by being grown close to other varieties, they have some advantages. You can be sure that your seeds come from plants that are adapted to your climate and soil and from fine individual specimens. With bought seeds you usually have no assurance on these points.

Fig. 129. Onions trimmed ready for transplanting.

In saving seeds select only the best specimens from the type of plant that you wish; allow the fruit to ripen fully and then dry the seeds thoroughly in the sun before putting them away. They should be placed where they will be dry,

GARDENER'S PLANTING TABLE

Quantity of seeds or number of plants required for a row 100 feet in length, with distances to plant, times for planting, and period required for production of crop

Brackets indicate that a late or second crop may be planted the same season.

Kind of vegetable.	Seeds or plants required for 100 feet of row.	Distance for plants to stand— Rows apart. Horse cultivation.	Distance for plants to stand— Rows apart. Hand cultivation.	Distance for plants to stand— Plants apart in rows.	Depth of planting.	Time of planting in open ground. South.	Ready for use after planting.
Artichoke, Globe	½ ounce	3 to 4 ft.	2 to 3 ft.	2 to 3 ft.	1 to 2 in.	Spring	15 months.
Artichoke, Jerusalem	2 qts. tubers	3 to 4 ft.	1 to 2 ft.	1 to 2 ft.	2 to 3 in.	Spring	6 to 8 months.
Asparagus, seed	1 ounce	30 to 36 in	1 to 2 ft.	3 to 5 in.	1 to 2 in.	Autumn or early spring	3 to 4 years.
Asparagus, plants	60 to 80 plants	3 to 5 ft.	12 to 24 in	15 to 20 in	3 to 5 in.	Autumn or early spring	1 to 3 years.
Beans, bush	1 pint	30 to 36 in	18 to 24 in	5 or 8 to ft	½ to 2 in.	February to April. [August to September.]	40 to 65 days.
Beans, pole	½ pint	3 to 4 ft.	3 to 4 ft.	3 to 4 ft.	1 to 2 in.	Late spring	50 to 80 days.
Beets	2 ounces	24 to 36 in	12 to 18 in	5 or 6 to ft	1 to 2 in.	February to April. [August to September.]	60 to 80 days
Brussels sprouts	¼ ounce	30 to 36 in	24 to 30 in	16 to 24 in	½ in.	January to July	90 to 120 days.
Cabbage, early	¼ ounce	30 to 36 in	24 to 30 in	12 to 18 in	½ in.	October to December	90 to 130 days.
Cabbage, late	¼ ounce	30 to 40 in	24 to 36 in	16 to 24 in	½ in.	June and July	90 to 130 days.
Cardoon	½ ounce	3 ft.	2 ft.	12 to 18 in	1 to 2 in.	Early spring	5 to 6 months.
Carrot	1 ounce	30 to 36 in	18 to 24 in	6 or 7 to ft	½ in.	March and April. [September.]	75 to 110 days.
Cauliflower	¼ ounce	30 to 36 in	24 to 30 in	14 to 18 in	½ in.	January and February. [June.]	100 to 130 days.
Celeriac	¼ ounce	30 to 36 in	18 to 24 in	4 or 5 to ft	⅛ in.	Late spring	100 to 150 days.
Celery	¼ ounce	3 to 6 ft.	18 to 36 in	4 to 8 in.	⅛ in.	August to October	120 to 150 days.
Chervil	1 ounce	30 to 36 in	18 to 24 in	3 or 4 to ft	1 in.	Autumn	1 year.
Chicory	¼ ounce	30 to 36 in	18 to 24 in	4 or 5 to ft	½ in.	March and April	5 to 6 months.
Citron	1 ounce	8 to 10 ft.	8 to 10 ft.	8 to 10 ft.	1 to 2 in.	March and April	100 to 130 days.
Collards	¼ ounce	30 to 36 in	24 to 30 in	14 to 18 in	½ in.	May and June	100 to 120 days.
Corn salad	2 ounces	30 in.	12 to 18 in	5 or 6 to ft	½ to 1 in.	January and February. [Sept. and October.]	60 days.
Corn, sweet	¼ pint	36 to 42 in	30 to 36 in	30 to 36 in	1 to 2 in.	February to April	60 to 100 days.
Cress, upland	½ ounce	30 in.	12 to 18 in	4 or 5 to ft	½ to 1 in.	January and February. [Autumn.]	30 to 40 days.
Cress, water	½ ounce	Broadcast	......	......	On surface.	Early spring	60 to 70 days.

Cucumber	½ ounce	4 to 6 ft.	4 to 6 ft.	4 to 6 ft.	1 to 2 in.	February and March. [September.]	60 to 80 days.
Dandelion	¼ ounce	30 in.	18 to 24 in	8 to 12 in.	½ in.	Early spring or autumn	6 to 12 months.
Egg-plant	⅛ ounce	30 to 36 in	24 to 30 in	18 to 24 in	½ to 1 in.	February to April	100 to 140 days.
Endive	1 ounce	30 in.	18 in.	8 to 12 in.	¼ to 1 in.	February to April	90 to 180 days.
Horseradish	70 roots	30 to 40 in	24 to 30 in	14 to 20 in	3 to 4 in.	Early spring	1 to 2 years.
Kale, or borecole	¼ ounce	30 to 36 in	18 to 24 in	18 to 24 in	½ in.	October to February	90 to 120 days.
Kohlrabi	¼ ounce	30 to 36 in	18 to 24 in	4 to 8 in.	¼ in.	September to March	60 to 80 days.
Leek	½ ounce	30 to 36 in	14 to 20 in	4 to 8 in.	1 in.	May to September	120 to 180 days.
Lettuce	½ ounce	30 in.	12 to 18 in	4 to 6 in.	½ in.	September to March	60 to 90 days.
Melon, muskmelon	½ ounce	6 to 8 ft.	6 to 8 ft.	Hills 6 ft.	1 to 2 in.	February to April	120 to 150 days.
Melon, watermelon	1 ounce	8 to 12 ft.	8 to 12 ft.	Hills 10 ft.	1 to 2 in.	March to May	100 to 120 days.
Mustard	¼ ounce	30 to 36 in	12 to 18 in	4 or 5 to ft	¼ in.	Autumn or early spring	60 to 90 days.
New Zealand spinach	1 ounce	36 in.	24 to 36 in	12 to 18 in	1 to 2 in.	Early spring	60 to 100 days.
Okra, or gumbo	2 ounces	4 to 5 ft.	3 to 4 ft.	24 to 30 in	1 to 2 in.	February to April	90 to 140 days.
Onion, seed	1 ounce	24 to 36 in	12 to 18 in	4 or 5 to ft	½ to 1 in.	October to March	130 to 150 days.
Onion, sets	1 quart of sets	24 to 36 in	12 to 18 in	4 or 5 to ft	1 to 2 in.	Early spring	90 to 120 days.
Parsley	¼ ounce	24 to 36 in	12 to 18 in	3 to 6 in.	⅛ in.	September to May	90 to 120 days.
Parsnip	½ ounce	30 to 36 in	18 to 24 in	5 or 6 to ft	½ to 1 in.	...	125 to 160 days.
Peas	1 to 2 pints	3 to 4 ft.	30 to 36 in	4 or 5 to ft	2 to 3 in.	September to April	40 to 80 days.
Pepper	⅛ ounce	30 to 36 in	18 to 24 in	15 to 18 in	½ in.	Early spring	100 to 140 days.
Physalis	⅛ ounce	30 to 36 in	18 to 24 in	18 to 24 in	½ in.	March to May	130 to 160 days.
Potato, Irish	5 lbs. (or 9 bu. per acre).	30 to 36 in	24 to 36 in	14 to 18 in	4 in.	January to April	80 to 140 days.
Potato, sweet	3 lbs. (or 75 slips).	3 to 5 ft.	3 to 5 ft.	14 in.	3 in.	April and May	140 to 160 days.
Pumpkin	½ ounce	8 to 12 ft.	8 to 12 ft.	Hills 8 to 12 ft	1 to 2 in.	April and May	100 to 140 days.
Radish	1 ounce	24 to 36 in	12 to 18 in	8 to 12 to ft.	½ to 1 in.	September to April	20 to 40 days.
Rhubarb, seed	½ ounce	36 in.	30 to 36 in	6 to 8 in.	½ to 1 in.	...	2 to 4 years.
Rhubarb, plants	33 plants	3 to 5 ft.	3 to 5 ft.	3 ft.	2 to 3 in.	...	1 to 3 years.
Rutabaga	¼ ounce	30 to 36 in	18 to 24 in	6 to 8 in.	½ to 1 in.	August and September.	60 to 80 days.
Salsify	1 ounce	30 to 36 in	18 to 24 in	2 to 4 in.	½ to 1 in.	...	120 to 180 days.
Spinach	1 ounce	30 to 36 in	12 to 18 in	7 or 8 to ft	1 to 2 in.	September to February	30 to 60 days.
Squash, bush	½ ounce	3 to 4 ft.	3 to 4 ft.	Hills 3 to 4 ft.	1 to 2 in.	Spring	60 to 80 days.
Squash, late	½ ounce	7 to 10 ft.	7 to 10 ft.	Hills 7 to 9 ft.	1 to 2 in.	Spring	120 to 160 days.
Tomato	⅛ ounce	3 to 5 ft.	3 to 4 ft.	3 ft.	½ to 1 in.	December to March	100 to 140 days.
Turnip	½ ounce	24 to 36 in	18 to 24 in	6 or 7 to ft	¼ to ½ in.	August to October	60 to 80 days.
Vegetable marrow	½ ounce	8 to 12 ft.	8 to 12 ft.	Hills 8 to 9 ft.	1 to 2 in.	Spring	110 to 140 days.

Courtesy of the U. S. Department of Agriculture

well ventilated, not subject to great changes in temperature, and not liable to suffer from mice, rats, or insects.

215. **Garden Pests.**—Insects and diseases are discussed in another chapter, but a few additional practical suggestions here for young gardeners will be helpful. Where there are only a few or especially valuable plants to protect, the cutworm, which destroys so many fine young vegetables, may be kept out by wrapping the stems of plants with a thin soft paper when they are transplanted. The paper should be loosely rolled around the stem and the plant so set in the soil that the paper extends below the surface far enough to hold it in place. The paper soon disintegrates or may be removed after the plant is large enough to protect itself. Another successful plan is to surround the young plant with a tin ring which extends about an inch above and an inch below the surface of the soil, and stands about an inch from the plant all around. By melting the tops and bottoms from old tin cans and cutting the cans in circular strips about two inches wide, these rings can be made at no expense except the labor. They will last for years. In order to make it easy to remove the rings from the plants they should be slit, so that they are merely bent around the plant and held in place by the soil. Figure 130 shows such protectors in place.

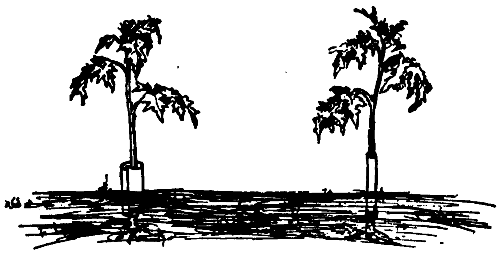


FIG. 130. Paper and tin shields for young plants in a small garden.

In addition to protecting the plants from cutworms, all means for destroying these worms should be employed without ceasing. They should be destroyed by hand and by poison, and no remnants of crops should be left ungathered for them to feed on, so that they thrive and multiply. A few worms left will develop into moths that will lay eggs enough to fill the garden with worms again. The moths should also be attacked by such means as are suggested in the references. All weeds and grass should be kept out of the garden, and the fields immediately adjoining it should be cultivated and kept clean. Spasmodic fighting of such pests accomplishes little, but persistent intelligent work brings them under control.

The insects which destroy so many young melon, cucumber, and other similar plants can often be guarded against economically by the use of wire-netting cages, which can be made for about two cents apiece and which last for years. Such a cage is easily made by cutting strips from thirty-six-inch wire netting. Ravel out one or two wires on one side and on one end of a piece of netting six by eighteen inches in size. Bend this strip and make a hoop about six inches in diameter by running the loose ends of the wire at one end of the strip through the meshes at the other end, and bending them back so as to hold the two ends together. Then cut a piece seven inches square and press it down on top of the ravelled end of the hoop, and work the loose ends of the wires of the hoop through the meshes of the top piece, and bend these down so as to hold the top on. Such a cage keeps out insects and shades the young plants slightly. When the plants are tough enough to withstand attacks, the cages are lifted off and put away for future use.

Toads, horned lizards, and birds should be encouraged in the garden, as they are great natural insect destroyers. Toads should be kept in the hot-beds, cold-frames, and seed-beds. Young fowls, before they are old enough to do harm by scratching or pecking the vegetables, will destroy great numbers of insects.

The Questions, Problems, and Exercises and the References for Further Reading on the garden will be given at the end of the next chapter.

CHAPTER IX

SCHOOL GARDEN AND FARM

216. **Every School Should Have a School Garden.**—Each pupil should have a home garden and put into practice there the things that he learns in school. The work is more interesting and instructive if there is also a school garden. With even as little as a quarter of an acre forty-two pupils may each have an individual plat five by fifteen feet, and still half the land be left for trees, shrubs, flowers, experimental tests, and general observation plats. It is better, however, if the garden for this number covers a half acre, as shown in Figure 124. To this garden with its small experiment plats should be added several acres of farm for larger experiments and for observation. In some places such school farms are made a valuable source of income for the school each year. It is certainly possible in every rural community to secure by donation one or more acres for the school garden and farm. Every rural school should have from five to ten acres of land attached to it. Patrons and friends gladly contribute the needed manure, fertilizers, and work of teams when these cannot be secured out of the school funds. The work in the garden is a pleasant diversion for both teacher and pupils and in nowise interferes with the other work of the school.

217. **How the School Garden is Laid Out.**—The school garden should have around it attractive borders of flowers set against a background of shrubs. There should also be

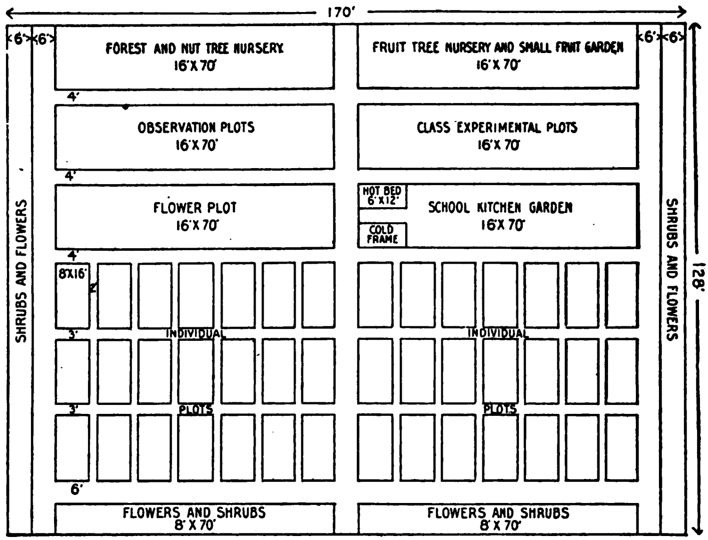


Fig. 131. A good layout for a half-acre school garden where there are only a few pupils.

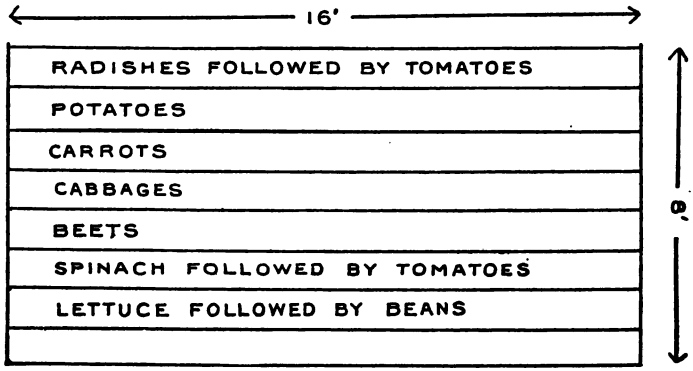


Fig. 132. A good planting plan for the pupil's individual plat.

one plat set aside for the cultivation of flowers. One should be devoted to a nursery for forest and nut trees. In this the seedlings are raised, with which part of the practice in grafting, budding, pruning, and transplanting is obtained. Another plat devoted to fruit trees serves in part the same

Fig. 133. A view in the practice school garden at the University of Texas.
Courtesy of A. S. Blankenship, University Lecturer on Rural Schools.

purpose, and gives opportunity for the study of insects and diseases, and for learning how to care for fruit trees. Another plat is devoted to demonstrations for observation by the entire class of such things as the effect of different varieties of seeds, different methods of tillage, etc. In another plat experiments may be carried on by either teacher or pupils or both. In still another a kitchen garden for use of the school may be cultivated. Besides these large plats there should be a small individual plat, about eight by sixteen feet, for each pupil. This plat should be cared for entirely by the pupil, under the direction of the teacher. An accurate and

Fig. 134. A good set of tools.
Courtesy of Edward Mahoney.

neat account of all work done, and of the results, should be kept by the pupil and handed in to the teacher for criticism and suggestion. The short plats necessitate the doing of all work by hand, but as the object is to help the pupils learn how to handle plants, this uneconomical plan is justified.

218. **What to Plant in the Individual Plat.**— No list of vegetables for the individual plat is equally good for all sections. The season of the year, the soil, and the local climatic conditions must determine what is best. The list shown in Figure 132 suits well for the spring in Austin. A garden started in the fall, as gardens should be, would have such vegetables as radishes, lettuce, spinach, turnips, onions, and cabbages. The list should include some vegetables that are

Fig. 135. A good showing; a happy boy. *Courtesy of Edward Mahoney.*

Fig. 136. School-boys corn, school farm, Uvalde, Texas.
Courtesy of A. S. Blankenship, University Lecturer on Rural Schools.

grown for their underground parts, some for their leaves and stem, some for their fruit and seeds, some that require transplanting, some that come quickly to maturity, and some that are slow. It should include vegetables that the pupils and the pupils' parents especially like.

FIG. 137. A view of the school farm, Bonham, Texas.
Courtesy of A. S. Blankenship, University Lecturer on Rural Schools.

219. **Tools and Seeds.**—The expense of tools is small, and even where it is impossible for the school to furnish each child an individual set of tools such as is shown in Figure 134, the school can purchase a few tools for general use, and have each child bring his tools from home when needed. Seeds are also inexpensive. By writing to the Congressman from the district it is possible to secure from the United States Department of Agriculture a considerable supply of excellent seeds free of charge. After the first year a large part of the seeds should be saved from the garden.

220. **The School Farm.**—In addition to the garden with its small plats there should be a farm of several acres to afford opportunity for larger demonstrations of different crops, of rotation, different methods of tillage, orcharding, combatting insects and other pests, fertilizer and manure tests, breeding, selection, etc. The school farm should be the community experimental plat for trying out and introducing new crops, better suited varieties, and more economical and efficient methods of cultivation.

221. **Keeping Records.**—Neat and accurate records of all work should be kept by both pupils and teacher. On page 230 there are samples of desirable types of records.

There are several plans by which teachers grade the work done by pupils on the individual plats. The system of scoring indicated by the report blank on page 231, used by Mr. C. H. Winkler in grading the individual work in the University of Texas school garden, is a very satisfactory one.

222. **A Good School Garden and Farm.**—The following account from the *Boston Journal of Education* of a school garden in Utah gives an idea of what any school with progressive principal and teachers may accomplish. For Southwestern conditions, of course, other plants should be substituted for some of those in this garden.

"There are ten acres in the garden, of which two acres are reserved for dry farming, and on the other eight acres are:

"Two hundred and eighty fruit trees, embracing every fruit that is raised for commercial purposes in the State.

"Twenty kinds of garden vegetables.

"Five cereals.

"Two fibre plants.

RECORD OF GARDEN WORK

DATE	WORK	OBSERVATIONS
Sept. 10....	Spaded and raked garden	Found many earthworms. Soil moist, pulverized easily
Sept. 11....	Planted one row each —— radish and —— spinach Planted in seed-bed —— lettuce seeds	Covered seeds very lightly, tramped them, raked over them a thin cover of loose soil
Sept. 12....	Planted —— onion sets	

PLANT RECORD

Name of Plant		Lettuce
Variety		California
Time of Planting		Oct. 10, 1 hour
No. of Rows		2
No. of Plants or Seeds		42 plants
Worked		Oct. 11, watered 20 min.
Worked		Oct. 13, watered 20 min.
Worked		Oct. 20, cultivated 20 min.
Worked		Oct. 28, cultivated 10 min. Nov. 15, tied up heads, cultivated 1 hr.
Harvested		40 heads, Dec. 1 to Jan. 1
Enemies	Insects	Worms destroyed two plants
Enemies	Fungi	
Remarks		Lettuce worth $3

REPORT ON INDIVIDUAL PLATS

PLAT No.	1	2	3	4	5	6	7	8	9	10
1. General Appearance (20)										
a. Rows straight 5										
b. Rows in line 5										
c. Stand 10										
2. Layout (20)										
a. Space between rows 10										
b. Arrangement 10										
3. Tillage and Irrigation (50)										
a. Weeds 20										
b. Mulch 20										
c. Irrigation 10										
4. Harvesting (10)										
a. At proper stage 6										
b. Care in removal 4										
Total 100										

———————————— *Instructor.*

" One hundred and thirty fruit trees in nursery.

" Two rows asparagus, 165 feet long.

" Four rows red raspberries, 165 feet long.

" Two rows black raspberries, 165 feet long.

" Two rows blackberries, 165 feet long.

" Two rows rhubarb, 165 feet long.

" One row grapes, 165 feet long.

" Two rows gooseberries, 165 feet long.

" Two rows currants, 165 feet long.

" Several grasses.

" Three hundred and ten children's home gardens.

" There are one hundred and twenty children raising poultry at home.

" The best part of the garden is that it is managed on a business basis. Every cent paid out is charged to the crop upon which it is expended. Every crop bears its part of the general expense. A close and accurate account is kept of every cent of income, for everything raised is sold for market price. Everything is of the best variety, is prepared for market in the most approved manner, and is marketed in a business-like way.

" The seventh grade keeps the account, has a bank account, keeps track of all expenses. An account is kept with each crop, and with each plot of ground. The ordinary farmer's affairs are sloppy when compared with the financial affairs of this garden, kept by the seventh grade.

" The eighth grade has charge of civic affairs, of the larger business interests. For instance, when pupils began to market they had to buy a horse and market wagon, and get a city marketing license. All this fell to the lot of the eighth grade."

223. **The Inexperienced Teacher May Learn With the Pupils.**—If the inexperienced teacher will frankly confess her inexperience to her pupils, and will carefully study such guides as Parsons's or Green's books, and the Government bulletins, she will be able to succeed with a garden from the very start. These books and bulletins give full details, with numerous illustrations. By conference with successful local gardeners such adaptations to local conditions as are necessary can be learned. Mistakes will be made by both teacher and pupils, but if thoughtfully used the mistakes may teach valuable lessons. The University of Texas Department of Extension sends out free a little monthly, *Bulletin on Elementary Agriculture*, which tells each month what to do in the school garden, and gives other timely suggestions for the teaching of an elementary course in agriculture in Texas.

QUESTIONS, PROBLEMS, AND EXERCISES

120. How many days in the year do you eat green vegetables?
121. Are all of your dried and canned vegetables grown at home?
122. How large is your home garden?
123. What varieties of vegetables are grown in it?
124. Write out a practical plan for improving your home garden.
125. State where you would locate a garden on your place, and give your reasons for choosing this spot.
126. Tell the character of soil and subsoil on the spot chosen in the problem above, and state fully what you would do to bring this particular soil into the right condition.
127. Lay out a garden plan for a quarter-acre garden, similar to that in Figure 112, including especially the vegetables liked by your family. Be careful to have a succession of vegetables covering the year, and the land occupied all the year with some crop.
128. Get your father to allow you to carry this plan out next year. Keep an account of all expenditures and labor, and of the value of the vegetables used and sold. Report this to the school.

129. Watch for plants that are especially able to resist certain insects, diseases, or drought, as is shown by their surviving when the rest of the crop is destroyed. Save seeds of these, and breed up a resistant variety.
130. Select one vegetable crop, save seeds from the best specimen, and see how much you can improve this crop by selection during three years.
131. Outline a list of vegetable and farm crops for your school garden that will accomplish the following things:
    (1) Illustrate various methods of cultivation.
    (2) Illustrate various methods of harvesting.
    (3) Illustrate the principal local crops.
    (4) Illustrate desirable rotations.
    (5) Test out a few crops to see if they can be profitably introduced into the locality.

REFERENCES FOR FURTHER READING

* "Productive Vegetable Growing," J. W. Lloyd.
* "Garden Farming," L. C. Corbett.
"Subtropical Vegetable Gardening," P. H. Rolfs.
"Principles of Vegetable Gardening," L. H. Bailey.
"Garden Making. Suggestions for the Utilization of Home Grounds," L. H. Bailey.
"Vegetable Gardening," R. L. Watts.
"Children's Gardens for Pleasure, Health, and Education," H. G. Parsons.
"Among School Gardens," M. L. Green.
"How to Make School Gardens," H. D. Hemenway.

Farmers' Bulletins:
No. 218. "The School Garden."
No. 232. "Okra, Its Culture and Uses."
No. 254. "Cucumbers."
No. 289. "Beans."
No. 354. "Onion Culture."
No. 856. "Diseases and Insect Enemies of the Home Vegetable Garden."

No. 934. "Home Gardening in the South."
No. 1044. "The City Home Garden."
No. 1242. "Permanent Fruit and Vegetable Gardens."

The A. and M. College of Texas Extension Service:

Bulletin No. B-44. "A Home Garden."
Farm and Home Hints on "Growing and Pruning Tomatoes" and "Storing Irish Potatoes for Fall Planting."

CHAPTER X

FRUIT-GROWING AND SHADE-TREES

224. The Home Fruit Garden and Commercial Orchards.—With fruits as with vegetables we must first learn about the home fruit garden. The growing of fruits in large quantities for the market or commercial orcharding must be left for later study in the references and in advanced courses in *horticulture* (hôr′tĭ-kŭl-tûr), the branch of agriculture which deals with garden and orchard crops. Horticulture comes from the Latin words *hortus*, a garden, and *cultura*, cultivation. Fruit-growing for the market is a very profitable business in many parts of Texas, and as soon as more growers learn the science of horticulture it will be more so. A study of the home fruit garden, or home orchard, will be the best beginning in this subject.

225. Value of Home-Grown Fruits.—For thousands and thousands of years before man learned to plant field crops and vegetables, or to cook his food, fruit made up a large part of his diet. Sound ripe fruit is still one of the most wholesome and delicious of foods. We need such food in both summer and winter to keep ourselves at the highest point of physical and mental power. At present a large part of the market fruit is picked when green, is ripened unnaturally, and is frequently stored for long seasons in great refrigerators, so that it is not only expensive but often tasteless and unwholesome when it reaches the consumer. Every

farmer at very small expense can produce at home far better and more wholesome fruit than he can buy; for the tenderest and most delicious varieties of fruit are not usually raised for the market, as, with a few exceptions, they do not keep

FIG. 138. Home-canned fruit on a Texas farm.
Courtesy of "Farm and Ranch."

well nor stand the rough handling in shipping. Let us therefore learn how to grow fruits at home.

226. **Fruits at All Seasons.**—It is possible to have a succession of fruits ripening during almost the entire growing season, and to finish out the year with stored fruits, grape juice, canned and dried fruits, marmalade, jams, and fruit butters, all prepared at home at small expense. With fruits as with vegetables, no one list will suit all sections. Oranges and lemons which grow in south Texas will freeze in central Texas. Apples that make splendid crops in north

Texas, do not succeed as well in south Texas. Cherries and gooseberries which are popular in the North cannot stand the hot, dry summer of the Southwest. Each one must learn by inquiry and experiment just what fruits grow well in his locality. If possible, every home should have some of

FIG. 139. A four-year-old fig orchard at Algoa, Texas.

each of the following: strawberries, raspberries, blackberries, dewberries, plums, apricots, peaches, pears, apples, persimmons, figs, grapes, and, in the semi-tropical districts, oranges, lemons, and pomegranates. The strawberries give the earliest fruit, followed by the other berries, the plums, apricots, apples, peaches, and pears. There are so many varieties of peaches which ripen at such different seasons, and grow well over such a wide area, that a well-selected orchard will furnish fresh peaches from June until late fall. Apples have even a wider distribution. Every wise farmer

should test out new fruits and new varieties occasionally, as only in this way can he learn just what is suited to his soil and climate. However, in most cases, it is best to plant such fruits as neighbors and near-by nurserymen have tested and found suitable.

227. **Where to Locate the Orchard.**—The orchard should be located on a hill-side, where the drainage is good and where the trees are somewhat protected from the cold winds. If planted in a bottom, the trees are apt to bloom too early and cause the crop to be destroyed by late frosts. Fungus diseases also are more troublesome in valleys. No one soil suits all fruits equally well. All demand good drainage. The plum, quince, and pear do best on a heavy soil, peaches on a rich sandy loam. Some varieties of grapes do well on a heavy soil, some on either a heavy or a light soil, and some only on a light soil. The soil should not be very rich in nitrogen, as this tends to produce too much vine and little fruit. If there is no soil perfectly suited to a mixed orchard, it is possible to improve it greatly before the trees are planted by adding sand, ashes, humus, or whatever is needed by each fruit to the particular spot on which it is to be planted.

228. **How to Plant an Orchard.**—Orchards are usually planted in regular rows according to the plan shown in Figure 140. The equilateral triangle method shown in Figure 141 gives a more even distribution on the land and enables one to put more trees on the same amount of ground without crowding. The rows should be carefully laid off and trees so planted that the straight rows show plainly from all directions. Peach-trees are usually set about sixteen to twenty feet apart, apples from thirty to forty feet,

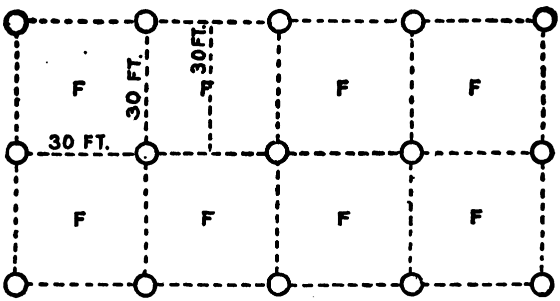


FIG. 140. Planting in squares.

bunch grapes in rows eight, and blackberries in rows six feet apart.

You have already learned about transplanting, and therefore know before being told that fruit trees should be moved when dormant, that from one-half to two-thirds of the top should be cut off, that the roots should be disturbed as little as possible, should never be allowed to dry, should have all bruised and broken parts trimmed off smooth, should be spread out in natural order in the ground, should be set in

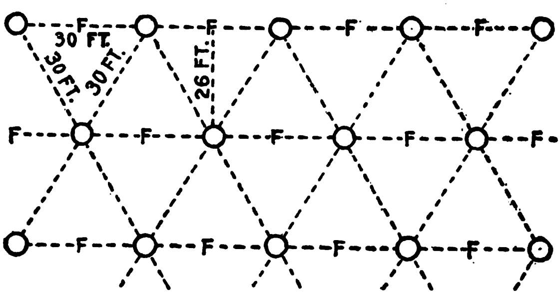


FIG. 141. The equilateral triangle-planting plan, which, by giving a better distribution over the land, allows more trees per acre without crowding than does the square-planting plan.

moist soil, and should have the soil packed closely around them. While it is usually not practicable to move soil and root together, it is well to take as many healthy roots as possible. As soon as dug the roots of the young tree should be covered with a moist wrapping, carried to the orchard,

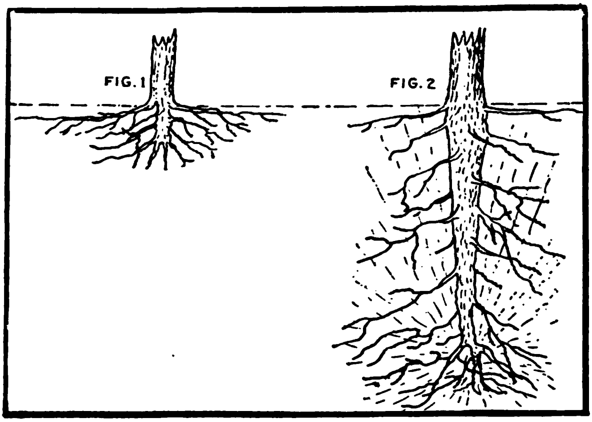


FIG. 142. The tree on the right was planted in a hole that had been dynamited. The hole on the left had not been dynamited. Note the increased root growth and deeper rooting in the dynamited hole.

Courtesy of "Farm and Ranch."

and never uncovered until the hole is dug and all is ready, so that the roots can at once be covered with soil.

The hole for a tree should be dug large enough to receive the roots in natural order. If the roots are too long to do this economically, they should be cut back somewhat. They should not be doubled up. The soil should be loosened up a spade's depth below the bottom of the hole. Unless the top soil is very deep it is usually advisable, after the hole is dug and before the tree is set, to bore down with an earth auger about three feet below the bottom of the hole and

break up the subsoil with a blast of dynamite. This is very easy to do, and is not dangerous work if the proper precautions are used. The directions are given in pamphlets sent out by the manufacturers upon request. It is not advisable for young boys to attempt the use of dynamite. The dynamite loosens the soil and makes large storage room for soil water, so that the roots of the plant not only go down more easily but have a better water supply. When the hole is being dug the top soil should be thrown on one side, as it is usually the best soil, and should be put back into the hole immediately touching the roots. Manure should not be placed in contact with the roots, though it is sometimes advisable in poor land to put some well-rotted manure in the hole away from the roots and in the soil that is used for filling in above them. The trees should be set in the orchard as deep as they grew in the nursery or about two inches deeper. The soil should be tramped well around the roots and loose soil raked over the surface of the packed soil.

229. **How to Handle Bought Trees.**—When trees are bought from a nursery-man they should be planted out as soon as received. Each should be taken from the wrapping only after the hole is prepared and when it can be immediately covered with moist earth. Many transplanted trees die because the roots were allowed to lie exposed to the air until they were dried out. In case it is not practicable to plant the trees as soon as received, open up in a well-drained spot a sloping trench deep enough to admit all the roots and a bit of the stems of the young trees. Place the trees in this close together and cover with moist earth, packing it in carefully so that the roots are in close contact with the moist soil. If the soil is not moist, water should be poured into

the hole before the final layer of loose dirt is drawn around the trees. This temporary placing of plants in the soil for protection is called "*heeling in.*" If the soil is well drained and is kept moist, heeled-in plants will keep perfectly until a favorable transplanting season.

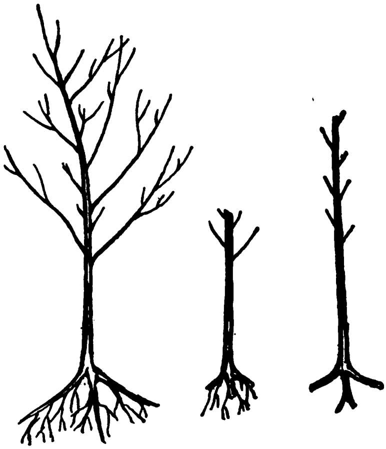


FIG. 143. Pruning nursery trees. On the right the tree is improperly pruned, not enough being taken off. The one in the centre is correctly pruned.—*After Halligan.*

230. **Pruning.**—All fruit trees, bushes, and vines require pruning, both to improve their appearance and to promote the most advantageous fruiting. Usually from one-fourth to one-half of the annual growth should be cut off for the first two years after planting. After this the pruning needed differs according to the circumstances and to the kind of fruit. The general aims of pruning should be to take out awkwardly shaped limbs, thin out the lateral branches so that sunlight can get in to the fruit, cut back the long branches so that they will not break with fruit, promote the growth of fruiting branches, and so direct the growth that the tree will be well proportioned and symmetrical. Trees should be pruned when dormant, though at times additional summer pruning is advisable. Many leading horticulturists now hold that summer pruning is very desirable, and that the shock thus given the tree tends to cause it

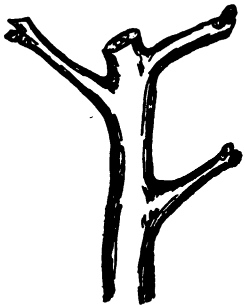


FIG. 144. Pruned to direct growth. The growth will be in the direction taken by the topmost bud left when the branch is cut off, as this bud grows most rapidly. This being true, in what direction will each limb in the cut above grow?

to fruit better. It is a well-known fact that when trees are severely injured they tend to put their energies at once into fruiting, as if the tree were trying to make sure of leaving a new generation in case of its death.

The apple and the pear bear their fruits upon short branches of the previous year's growth, called *fruiting spurs,* which grow out from limbs that are one year or more old. The bearing shoots are not usually the long ones near the ends of the branches. In pruning care must be taken, therefore, not to cut off too many of the short fruiting spurs. The peach bears on wood of the last season's growth, but directly on the branches instead of on spurs. With the peach cutting back the long branches is necessary in order to limit the crop and prevent the tree's breaking. The Japanese plum fruits on both spurs and year-old wood, and may well be cut back similarly to the peach. The quince bears its fruit at the end of new shoots of the present season's growth, so that the pruning must be such as will stimulate new growth without going so far as to limit too greatly the crop. The grape also bears fruit upon the shoots of the present season, which usually

FIG. 145. The right way to cut off the old stem after the new budded branch has got started.

come out from canes of the past season. For this reason the vines should be cut back severely each year, as the long canes of old wood bear no fruit. The Munson system of training, as illustrated in Figure 146, is recognized as standard, unless it is desired to make an arbor. The diagram makes this so plain that explanations are unnecessary. Even when the

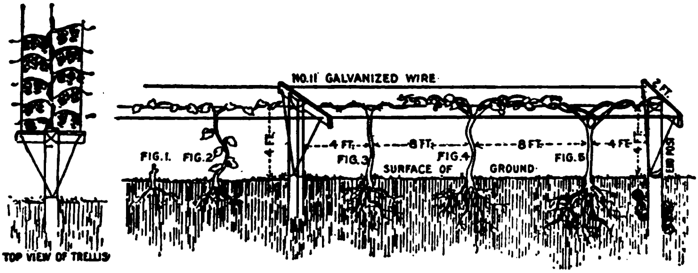


Fig. 146. The Munson system of grape culture.
From "Foundations of American Grape Culture."

shade of an arbor is desired, better results will be secured if the vines are planted close together, and the lateral branches trained out in regular order, and the canes cut back each year in a manner similar to that illustrated in Figure 146. Under this system the new growth will soon cover over an entire arbor each year, if the old canes have been properly trained and trimmed. In pruning the grape, care must be taken not to cut the vines just as the sap is beginning to flow in the spring. They may be safely cut later in the season, but the proper time for pruning is when the vine is dormant. Blackberries and raspberries also need severe pruning, as they bear their fruit on short shoots growing out from canes of the previous season's growth. Strawberries bear best the first year, and after two years should be taken out and room given to young plants.

231. **Cultivation.**—Fruit trees need cultivation for the same reasons that other plants need it. If weeds are left to absorb the food materials and water, and the soil allowed to crust over and the water to evaporate, a rapid growth of the trees cannot be expected. When trees are young and

FIG. 147. A young vine that shows how grapes flourish in the Southwest.

the roots short, it does no harm to plant vegetables or other shallow growing crops among them, but after the trees have been planted a few years, the soil should be cultivated clean during the growing season of the trees, so that the constant soil mulch will hold the water in the soil for the use of the trees. After the middle of the summer a fall crop of clover, oats, bur-clover, or other winter cover crop should be planted, as this protects the soil from winter washing and leaching

FIG. 148. Clean cultivation.

FIG. 149. Peas in the middles.

and supplies vegetable matter to turn under in the spring. If a legume is planted in this way, or in the middles earlier in the season, the amount of manure or fertilizer that should

Fig. 150. Gathering apples. The temperature fell to 17° at flowering time, but the orchard smudges saved this crop.

Courtesy of "Farm and Ranch."

be added is greatly lessened. Trees cannot be expected to bear heavy crops each year unless food materials are supplied. It is especially necessary that an abundant supply be given when a large crop is being borne, as the tree must during this season lay aside enough reserve food to mature all its fruit,

and also enough to start the new crop the next year, and sustain the tree until its new leaves are developed. It is usually unwise to allow the trees to bear very heavy crops. Peaches especially should be thinned, so that they are about five

FIG. 151. A young fruiting pecan-tree. The early fruiting varieties bear the second year after being budded and occasionally the first year.
Courtesy of "Farm and Ranch."

inches apart on the stem. This increases the size of the fruit and, by lessening the drain on the tree, makes it more likely that a crop will be produced the next year.

232. **Protection From Cold.**—In our changeable climate the loss of an entire fruit crop from early blooming and a late frost has been a serious drawback to the growing of fruit. Often the entire crop could be saved by protecting the

orchard one night. It has been found possible to do this economically, even in our windy country, by the use of slow-burning orchard fires, or *smudges,* as they are called. These fires are usually made by burning crude oil in the orchard in vessels which hold two or three gallons of oil, and are so constructed as to keep a slow fire burning for many hours on one filling. These have been known to raise the temperature of an orchard six to eight degrees. Where there is much wind the change in temperature is not so great. Another protection for the orchard is a row of evergreen trees on the side from which the cold winds usually come. Now that the use of these protections is understood, it is possible to save the fruit crop practically every year at a very small expense.

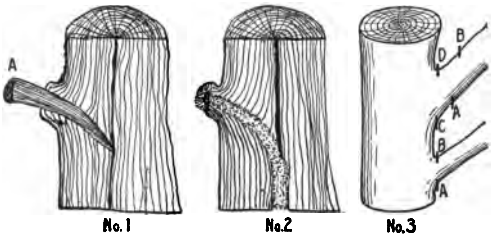


FIG. 152. No. 1. Limb cut off too far from the tree and cannot heal. No. 2. The same limb with the heart decayed and the decay carried into the heart of the tree (after Davis). No. 3. On the lower branch the right point at which to cut off a limb is shown. A cut should first be made one-third through on the under side of limb at *A*, in order to prevent splitting the tree. Then saw through from above at *B*. The upper branch illustrates the best method to follow when a very large limb is to be cut off and the danger of splitting is very great. Saw first at *A*, and then saw above a little further out on the limb until it breaks off. Then the limb may be easily cut off properly at *C D*.

233. **Nut-Trees.**—Every country home should have a few nut-trees. The native walnuts, hickories, and pecans grow in almost all sections when properly cared for. It seems probable that the budded and grafted Persian walnut, or " English walnut " as it is usually called, will also grow in many sections. Certainly the fine thin-shelled pecans,

the most delicious of all nuts, grow to perfection over a very large part of the Southwest. These trees grow and bear on the plains and on high hills, but do best along the river bottoms. For many years it was thought that pecans would not bear till ten or twelve years old, but varieties are now found and propagated which bear within two years of the time they are budded. Occasionally nuts are borne the first year after the tree is budded. With these early fruiting varieties, such as Halbert and Texas Prolific, which are most delicious "paper-shell" varieties, it is now possible to have a young pecan orchard bearing fair crops almost as soon as a peach orchard, if one cultivates and fertilizes properly the young trees. Furthermore, the best-selected varieties of pecans bear regularly. Wherever there is a native pecan-tree that is not giving a good annual crop of nuts, it should be cut back and grafted, or budded with a standard variety in the manner explained in Chapter III. When budded on large trees, the new buds grow much more rapidly than when set on nursery stocks, and hence a large fruiting is secured much earlier by budding on the old trees than by setting out a young orchard.

234. **Shade-Trees.**—The comfort and beauty of shade-trees are so much enjoyed by all that it is surprising to see so many homes and towns without shade. The fact that it takes so long for a tree to grow large enough to give shade is undoubtedly the principal cause of this neglect. Let us remember the joy and comfort given us by the trees planted by those who went before us, and prepare for our descendants and for our own middle life and old age by planting the splendid, long-lived trees, such as oak, elm, hickory, and pecan. Even in ten or fifteen years these trees will give

considerable shade. It is best when planting these slow-growing, long-lived trees to plant in between them the quick-growing, short-lived ones, such as the umbrella china-berry, the cottonwood, and sycamore. The hackberry is a tree of fairly rapid growth that makes a fine shade, will grow

FIG. 153. Decayed tree after and before being filled with conrete.

in almost any soil, stands drought well, and is comparatively free from insect attack. An objection to it is that it is very difficult to grow grass or flowers under it or near its roots. The proper methods of planting and caring for trees have already been given, and the methods of protecting fruit, nut, and shade trees from the ravages of insects and diseases will be given in the next chapter.

Warning should be given against the bad habit so often practised of sawing off short the stems of large trees, six inches or more in diameter, when transplanting, and of severely cutting back large shade trees every few years. When a tree is transplanted, the cambium layer is unable

FIG. 154. School-boys grafting an apple-tree in a neighbor's yard under the direction of the teacher.

Courtesy of U. S. Department of Agriculture.

to heal over the wound if the stem is cut off at a point at which the diameter is six or more inches. Decay will therefore soon enter the tree. The transplanted tree, when large, should be cut off higher up where the diameter is not over three or four inches, and the lateral branches thus left on

the stem should be cut back, leaving stubs one or more feet long. Care, however, must be taken not to allow more leaves to grow the first year than the crippled roots can supply with water. After the first year or so, unsightly branches should be cut out, the growth balanced and directed by pruning, and long limbs that are in danger of being broken by the wind cut back, but wholesale severe cutting spoils the natural gracefulness of the branches and retards the growth.

235. **Filling Decayed Trees.**—Through unwise pruning or through other mishap, many fine trees get decay in the heart wood. Unless arrested this will soon eat out all the heart wood, so that the tree will break in the first severe wind. Such decay may be arrested, and the life of the tree indefinitely prolonged, by proper treatment. All of the decayed material should be carefully cut away and cleaned out, the entire cavity washed thoroughly with an antiseptic solution* and then filled with concrete. The concrete is usually made with one part cement and two parts sand, or with equal amounts of each. The cavity is completely filled up to the edge of the growing wood, as shown in Figure 153. When the cement is set, the entire surface is covered over with coal tar, to make sure of filling all cracks. If properly done, this will prevent further decay, and if the opening is not too large, it will be covered slowly by new tissue thrown out by the cambium layer.

236. **The Arrangement of Shade-Trees.**—In the chapter on the School and Home Grounds, the proper arrangement of trees, shrubs, and flowers will be explained.

* The Bordeaux mixture and the formalin solution given on page 282 are good antiseptics for this purpose. An antiseptic (ăn-tĭ-sĕp'tĭk) is something that destroys the germs which produce disease.

QUESTIONS, PROBLEMS, AND EXERCISES

132. How much land is devoted to fruit on your farm? Give the number of trees or vines of each kind.
133. Select a spot for an orchard on your place and state why you select this spot, describing soil, subsoil, drainage, and protection.
134. Make out a planting plan for a home orchard for your family, giving a diagram of the proposed orchard and the location of each tree, bush, and vine, with names of varieties. State why each variety is selected.
135. State what you would do to the soil around each of the kinds of trees or vines that you plant.
136. State how you would handle this orchard each year, and what returns you should expect each year.
137. Working in pairs, let each two pupils set out under direction of the teacher either in the school orchard or at home at least two kinds of fruit trees and vines, getting actual experience in root and top pruning, and in correct planting.
138. Heel in correctly some young trees.
139. By use of the school orchard and of neighboring orchards, let each pupil, under the direction of the teacher, practise in pruning: (1) to direct growth, (2) to prevent breaking, (3) to regulate fruiting, and (4) to improve the appearance.
140. Prune and train two grape-vines according to the Munson system, and leave two equally vigorous vines of the same variety to run freely. Make an accurate measure of the fruit produced by each of these for three years.
141. Why is it better to have a tree bear 100 peaches that fill a bushel measure rather than 200 peaches that only fill the same measure? First, which crop will bring most money? Second, which will make the greater drain on the soil, and why so? Third, which will make the greater drain on the tree and make it less likely that the tree can bear a good crop the following year? Why so?
142. Make careful records each year of the number of hours it would be necessary to protect the orchards from cold in your locality. Compare the cost of such protection and the cost of the fruit losses.

143. How many nut-trees are there on your place? If there are any, cut off and top graft and top bud some of these. If there are none, plant nuts, and bud or graft the seedlings with fine varieties. Buds can be bought usually for a cent or two each from neighboring nursery-men.
144. Let each class plant one or more shade-trees on the school grounds, planting some slow-growing trees, such as the pecan, and some rapid-growing ones.
145. Find a decaying tree in the grounds or in a neighbor's yard, and with the aid of the teacher give a demonstration of filling the cavity with concrete.
146. Find edible wild fruits in your locality, pick out especially desirable specimens, transplant these, and see what improvement can be made in them by cultivation, by variation and selection, and by hybridization.

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No. 181. "Pruning."
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CHAPTER XI

PLANT ENEMIES

237. Varieties of Plant Enemies.—The enemies of the farm, garden, and orchard are usually grouped into five classes: (1) weeds, which injure crops by depriving them of light, water, and food materials; (2) animals and birds (while most birds are very helpful to crops through destroying harmful insects, a few do considerable damage); (3) parasitic plants, such as mistletoe; (4) insects; (5) diseases. In this course we shall consider only the insects and diseases, leaving the others for later study.

FIG. 155. An inexpensive cage in which to keep insects for study.

238. **Losses from Insects and Diseases.**—The annual losses from insects alone in this country are estimated at from three hundred million dollars to seven hundred million dollars. The loss on the potato crop alone is six million dollars, on cotton fifteen million dollars, on corn thirty-seven million dollars, on stored grain sixty million dollars. The Hessian fly destroys each year about five million dollars', the chinch-bug seven million dollars', and the boll-weevil eight million dollars' worth of crops. In many cases the losses were formerly much greater than they now are. In 1880 the cotton-worm alone did fifty million dollars' worth of damage.

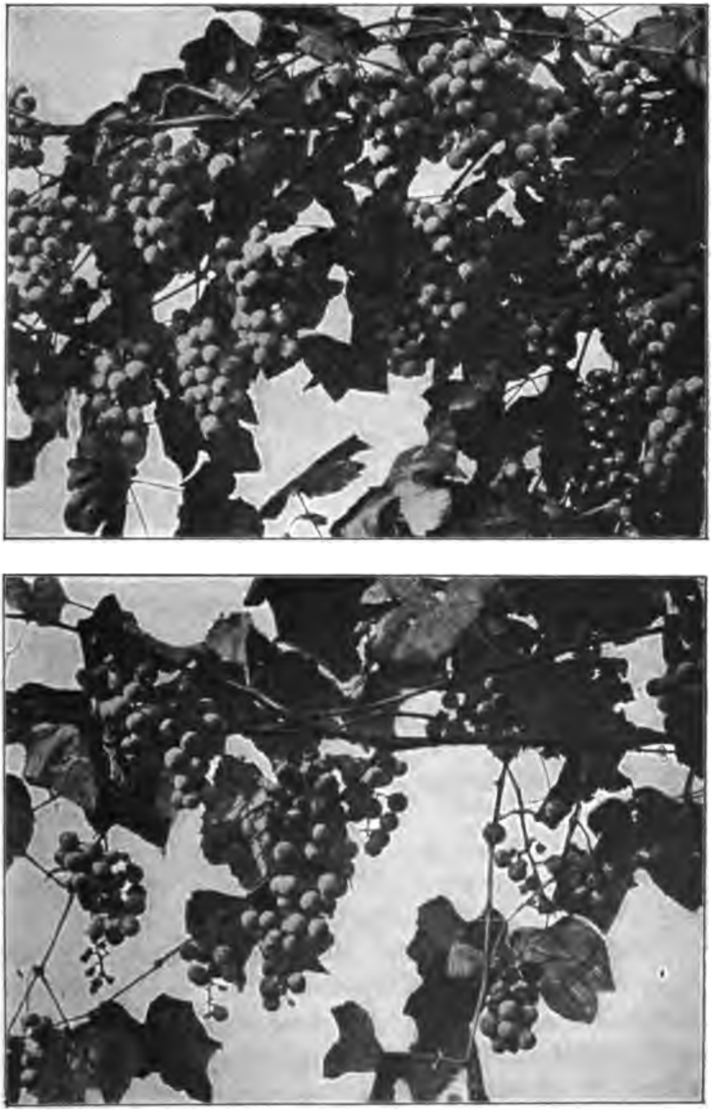

Fig. 156. Black rot on grapes: above, sprayed; below, unsprayed.
Courtesy of U. S. Department of Agriculture.

The losses from insects in Texas alone are estimated at fifty million dollars a year, about ten times the annual appropriation by the Legislature for all purposes, seven times as much as the State spends on its public schools, and eighty-five times as much as it appropriates for all the higher educational institutions. Effective means of combating many of these pests are now known and new means are constantly being discovered. It is estimated that if all farmers knew and applied what is now known about controlling insects, two-thirds of the crops lost each year could be saved. The yearly losses from disease are even larger than those caused by insects. These also can be largely prevented by making use of the knowledge already gained by scientific study.

FIG. 157. The Colorado potato-beetle: *a*, beetle; *b*, masses of eggs; *c*, half-grown larvæ; *d*, mature larvæ.
Courtesy of U. S. Department of Agriculture.

239. **Why Insect Pests Have Increased.**—There are many reasons why insects injurious to cultivated plants have increased in recent years. For these same reasons they will increase still more in future if proper precautions are not taken. In the first place the wild trees and plants have

been cut down and the land put under cultivation, so that the insects which formerly fed on wild plants must now feed on cultivated crops. These crops are grown with more certainty and regularity than the wild plants were, and hence support the insects better. Then, too, the cultivated places, which used to be more or less separated from one another, are coming more and more to be contiguous, so that the pests can pass directly from one field to another. Again, as more kinds of new plants are cultivated, the varieties of insects that attack these are multiplied and brought to our attention. Probably most effective of all in scattering these plant enemies have been the

Fig. 158. The cotton-boll weevil: *A*, as seen from above; *B*, as viewed from the side; *C*, larva; *D*, pupa. All about two and one-half times the natural size.
Courtesy of U. S. Department of Agriculture.

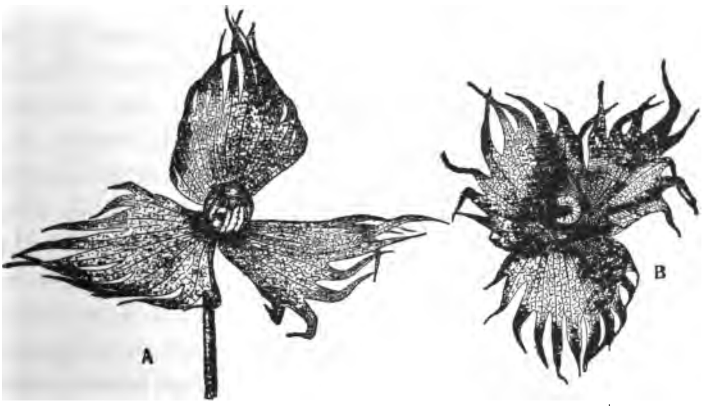

Fig. 159. *A*, square punctured by boll-weevil, showing the flaring back of the bracts; *B*, the weevil maturing within the boll.
Courtesy of U. S. Department of Agriculture.

improved means of transportation. Both insects and diseases are shipped into new districts along with foodstuffs, seeds, or nursery plants. It is for this reason that the transportation of seed, nursery stock, or other material likely to spread disease or insects should be strictly regulated by law.

240. **The Spread of Black Rot, Boll-Weevils, and Colorado Beetles.**—There are many remarkable examples of the spread of plant diseases. One of the most notable is the spread of the black rot of grapes. When the early settlers came to America they found the wild grapes here afflicted with this disease, which was then unknown in Europe. They sent some of these native vines back to Europe, with the result that this disease soon broke out in the European vineyards. Ever since that time this disease has caused great losses in the vineyards there, which must even yet be carefully sprayed to prevent very serious damage to the crop.

We have in America two recent instances of the rapid spread of a new insect pest. The ordinary potato-beetle, commonly called the "potato-bug," first appeared in the potato fields of Colorado about 1855. It had been living in that State on wild plants akin to the potato, and when the cultivated potato was brought to Colorado by settlers the beetles attacked it and throve on it so well that they multiplied and spread rapidly over the country. By 1864 they had extended to the Mississippi, and in 1874 reached the Atlantic States. The Mexican cotton-boll weevil crossed the Rio Grande about 1892. It had for years infested the cotton of Mexico, and in some districts had forced the abandonment of cotton cultivation altogether. In less than twenty years this pest spread nearly all over Texas, and is now ravaging the fields of Arkansas, Louisiana, and other Southern States.

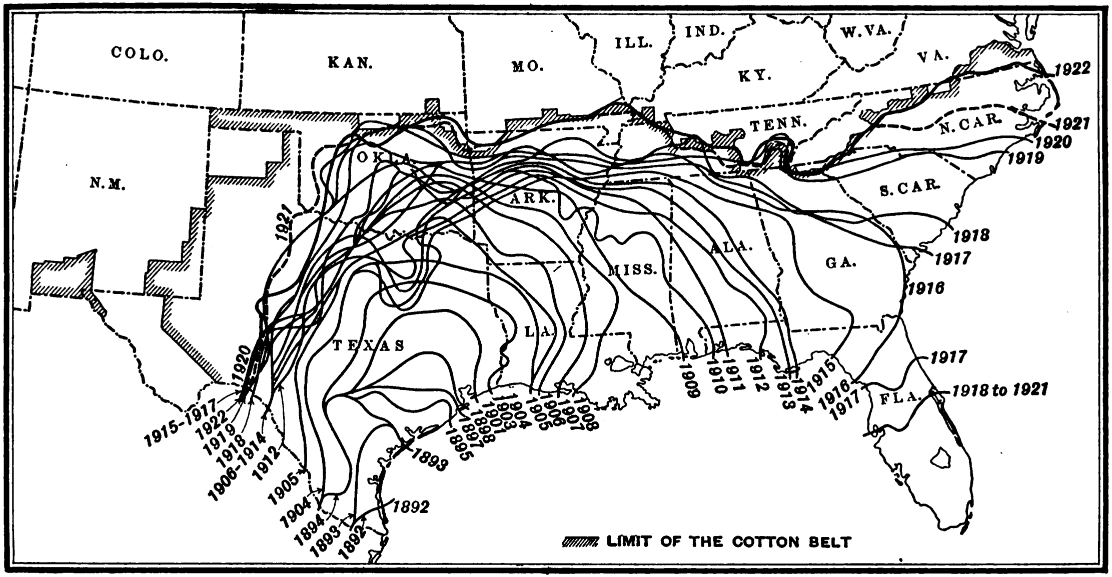

FIG. 160. Chart showing the spread of the Mexican cotton-boll weevil.
Courtesy of U. S. Department of Agriculture.

It will doubtless soon cover the entire cotton-growing area of America.

241. **What Must Be Known to Combat Plant Enemies.**—These facts show how extremely important it is that we obtain a knowledge of these insects and diseases, and of the means of controlling them. While the damages of only a few can be entirely prevented, it is possible to reduce greatly the damage of all, and to prevent their rapid increase and spread. Let us then first see what insects are, and how they live and multiply, for it is by knowing their habits and life history that we learn how to destroy or prevent them. After this we shall study the causes of plant diseases and learn the means of controlling them.

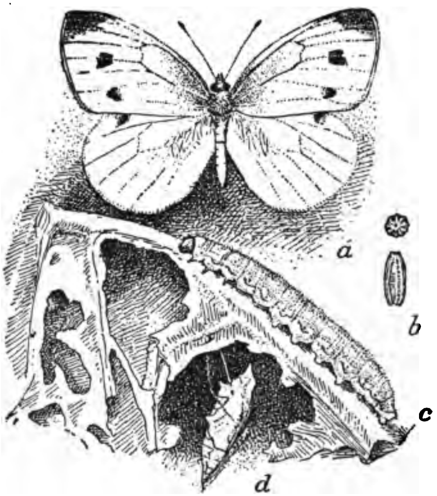

Fig. 161. The cabbage-worm: *a*, female butterfly; *b*, egg, end and side views; *c*, larva on leaf; *d*, suspended chrysalis.
Courtesy of U. S. Department of Agriculture.

242. **Insects.**—Insects are the most numerous of all forms of animal life visible to the naked eye. They vary greatly in appearance, but all have three pairs of legs and three distinct parts to their bodies, *head, thorax,* and *abdomen.* To the head are attached the *feelers,* or *antennæ* (ăn-tĕn′nē), the eyes, and the mouth parts. The thorax has three seg-

ments, to each of which is attached a pair of legs. In the adult stage one or two pairs of wings are also usually attached to the thorax. In nearly all cases insects hatch from eggs, and pass through several different forms before reaching their final shape. The typical insect passes through four stages, the *egg*, the *larva* (lär′vä), the *pupa* (pū′pä), the *adult*, or *imago* (ĭ-mā′gō). The larva may be entirely unlike the adult into which it will develop, as in the case of the caterpillar, which is the larva of a butterfly or a moth. During the larval stage the worm-like creature usually eats voraciously, does its great damage to crops, and grows rapidly until the skin hardens and refuses to grow further. Then it goes into a dormant-looking state and is called a pupa. The larva may spin a web case around itself, in which it lives as a pupa, or it may go into a cell in the ground or attach itself to a plant. While in its case the pupa (or *chrysalis* (krĭs′ȧ-lis) as it is called in the case of the butterfly) undergoes a wonderful change, and in due season comes out in the new form of the full-grown insect; as, for example, the ugly larval caterpillar pupates and comes out a beautiful butterfly or moth, and the cutworm becomes a moth. While the four stages—egg, larva, pupa, adult—are the usual stages, many insects omit one or two of

FIG. 162. Above, nymph of grasshopper in natural position; below, the empty pupa skin. *Courtesy of U. S. Department of Agriculture.*

these. For example, grasshoppers and several other insects are quite like the adult when hatched and have no pupa stage at all. These when young are called *nymphs* instead of larvæ.

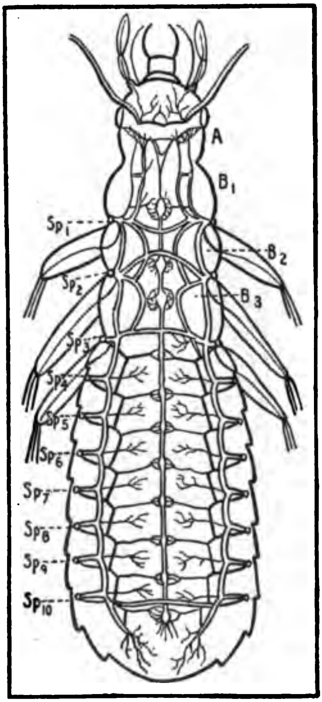

FIG. 163. A typical insect. *A*, head; B_1 to B_3, three segments of thorax, each with a pair of legs; Sp_1 to Sp_{10}, spiracles.—*After Kalbe.*

Many kinds of insects after passing through their various stages of growth and becoming adults live only long enough to deposit eggs, not even living to see their own young hatched. Others, like the boll-weevil, may live through a season, producing several sets of offspring. The time required by insects to pass through all their various stages, or *life cycle* (sī′kl), as it is called, varies from a few days or few weeks in most cases to many years in a few cases. Insects live from one season to the next often only in the form of eggs or pupæ. In other cases the adults that may be still active at the approach of cold weather hide away under leaves or grass or trash or bark or in basements, or burrow into the ground and remain quiet until spring—occasionally even being frozen without causing death. This spending of the winter in an inactive state is called *hibernation* (hī-bĕr-nā′shŭn). In spring

those hibernating insects that have not died become active again, lay eggs, and start a new generation.

243. **How Insects Feed and Breathe.**—Some insects feed by biting and chewing their food, as do the potato-beetle, grasshopper, and cotton-leaf worm. Others, such as the plant-lice, San José scale, and boll-weevil, puncture the plant and feed by sucking out the juices. Insects do not breathe through a mouth or nose as we do, but through a number of delicate little slits called *spiracles* (spĭr′å-klz) distributed along the sides of the thorax and abdomen. It is by a knowledge of the various stages through which insects pass, and of their eating and breathing characteristics, that successful methods of destroying them are devised.

FIG. 164. A bucket spray pump.

244. **How Insects Are Destroyed.**—If an insect gets its food by biting and chewing the plants, it is easy to destroy it by putting poison on the part attacked, as we put Paris green on the potato-plants to destroy the potato-beetle larvæ which eat the leaves. If the insect gets its food by puncturing the plant and sucking out the juice, then such poisons will not reach it. The sucking insects must be killed by contact poisons or by sprays that get into their breathing pores or spiracles and choke them to death, such as the oil emulsions, and lime and sulphur sprays, with which plant-lice and San José scale are destroyed. The formulæ for

making and directions for using the most important of these insect-destroying mixtures will be given later. Each insect usually has a very limited number of plants that it will eat. The ear-worm of corn will feed also on cotton, tomatoes, and tobacco; but many insects will feed on only one class of plants. By refraining for a year or two from planting the particular crops on which they feed, one may often starve to death insects which have a limited range of foods.

FIG. 165. A barrel spraying apparatus.

245. **General Methods of Combating Insect Pests.**—Besides being destroyed by poisons, insects may be very largely controlled by a wise general management of the farm through cleaning up the fields, destroying weeds and volunteer crops, deep fall plowing, trap crops, properly timing the crops, and the wise use of rotation.

When crops are harvested remnants are often left standing in the field on which insects continue to multiply until the end of the season, thus preparing fresh trouble for the

following year. These crop remnants should either be used to poison the insects or should be plowed under completely so as to bury some of the insects and leave no food for others. The wheat-worm and the corn-stalk borer both winter in the

FIG. 166. A power spraying apparatus.
Courtesy of "Farm and Ranch."

stubble of these crops. The boll-weevils continue to multiply on cotton until they hibernate. Many kinds of insects live in the grass, stubble, and rubbish left in parts of fields and along fence rows. Most of this should be turned under in the fall, and the fields and fence rows cleaned, only a few small piles of rubbish being left as traps. Hordes of insects will gather in these piles, which should then be burned. While usually all stubble should be turned under to enrich the soil, occasionally it is advisable to burn over stubble and

grass land to destroy such pests as army-worms, chinch-bugs, and locusts.

Weeds and volunteer crops are another means of supporting pests when there is nothing else left for them to eat.

Fig. 167. Apples from a sprayed tree. On the left are the perfect apples (98.3 per cent), on the right are the wormy apples (1.7 per cent). In an orchard of 325 trees twelve to twenty years old, the cost of spraying was 23 cents per tree, materials being bought at wholesale prices. The sprayed trees averaged over 95 per cent sound and the unsprayed only 58 per cent sound apples. The yield was increased from three to seven bushels per tree by spraying.

Courtesy of Ohio Agricultural Experiment Station.

The Hessian fly, for instance, feeds on volunteer wheat. Many larval forms also feed on weeds. The surrounding weeds are a great source of supply for garden cutworms.

In general, deep fall plowing is very helpful. In addition to turning under material on which the pests feed, or

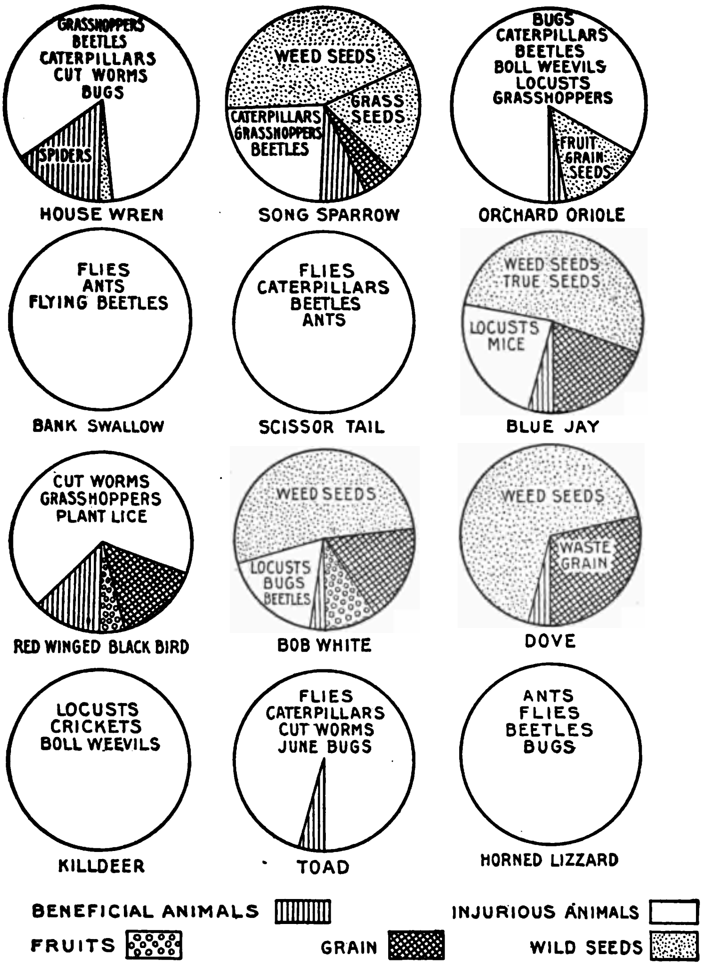

FIG. 168. The foods of some helpful birds and wild animals.
After Ferguson and Lewis.

in which they hibernate, it helps to destroy many larval forms in the ground, such as the corn-stalk borers, corn-ear worms, cutworms, locusts, and wire-worms. Some of these are broken, some brought to the surface where they die, and some buried so deep that they can never get out. Grasshopper eggs and boll-weevils are both said to be unable to do any harm if turned under as much as six inches.

At times trap crops, on which the insects feed, and by means of which they may be destroyed, are of great value. In this way the tomato, cotton, or tobacco crops, for example, may be protected from the worm which attacks all of them, and also the ears of corn, by planting a trap crop of corn. If this crop is planted around the field that is to be protected, the moths deposit their eggs on the corn silks, as they seem to prefer these to the other plants. Before the eggs can develop into moths, which would produce a new crop of eggs, the corn is cut and fed to horses, thus destroying the insects. By the planting of a succession of trap crops of corn the other crops may be largely protected.

By learning the time at which the insect does the most damage and planting so as to avoid this season, often one can avoid, to a great extent, the injury from that insect. In this way, by planting early varieties of cotton which mature a large part of their bolls before the boll-weevil becomes very plentiful, it has been possible to raise cotton profitably in spite of the weevil.

In a similar way, by forcing growth rapidly through the use of fertilizers, the damage from insects is often reduced. In some cases kainit, lime, and nitrate of soda are thought to have a tendency to drive out certain insects.

Rotation is also a very effective method of handling insect

pests. A crop that has been attacked by a certain pest should be followed by a different crop on which this insect cannot feed. In this way the pests developed one year find nothing which they can eat the next year. This is a matter that should always be carefully considered. For example, in a district in which corn-destroying insects are bad, one should see that land that has long been in pasture should not first be planted in corn, but in some other crop not related to the grasses, so that the insect pests that have accumulated in the grass will have nothing on which they can feed. Wire-worms, Hessian flies, wheat-plant lice, and many other serious pests may be largely controlled by rapid rotation, while the lack of rotation causes their very disastrous increase.

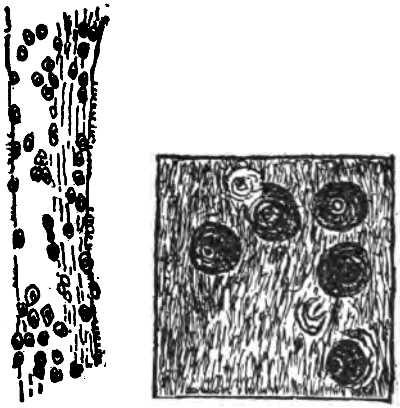

Fig. 169. San José scale. On the left in position on a small twig, on the right magnified.

246. **Natural Enemies of Insects.**—Insects are destroyed in nature especially by animal and plant parasites, by other insects, and by birds, toads, lizards, and snakes. Man should make use of these in his fight with insects. This has been done in many remarkable cases. For example, the lady-bird beetle, the larval form of which destroys scale insects, was introduced into the orange and lemon groves of California, and practically exterminated a white cottony cushion-scale

that had been causing losses of about five million dollars' worth of fruit a year. This little beetle saved also the cantaloupe-growing industry of California. Birds are among the farmer's most useful friends. In fact it is believed that the destruction of so many of our birds is one of the important

Fig. 170. Lady-bird beetle. Besides these with two spots there are many other kinds. One, about a quarter of an inch long with black head and body and orange wing covers on which are nine black spots, is very active against plant-lice. Another has thirteen black dots; one has pink head, thorax and wing covers, with ten spots on the wings. Those feeding on scales are smaller and black, sometimes spotted with red or orange. One should watch these, learn to recognize the larval forms, and not destroy them.

Courtesy of U. S. Department of Agriculture.

causes of the disastrous increase of insect pests. All insect-destroying birds should be protected most carefully by farmers, as they are worth far more as insect destroyers than is the little that they eat or the food that they supply when killed. The interesting detailed facts about the work of parasites, helpful insects, birds, and other animals must be left for study in the references and in advanced classes.

247. **The Causes of Plant Diseases.**—The main causes of plant diseases, as far as they are now known, are bacteria and fungi. You remember that these are tiny plants that

do not as a rule manufacture their own foods, and hence must take foods that other plants have made. In the case of the disease-producing fungi or bacteria, they take their food from the living plant, which they infect. A plant living thus on another plant is called a *parasite* * (păr′ȧ-sīt),

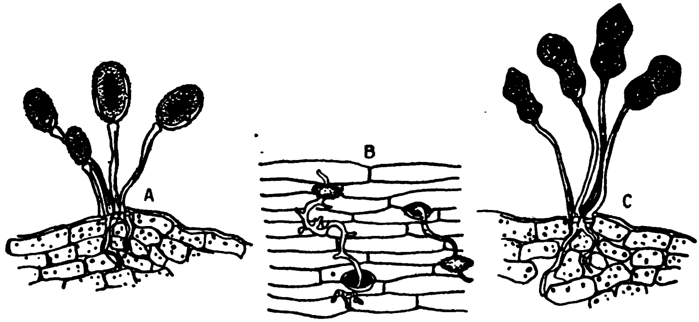

Fig. 171. Wheat rust. *A*, summer spores or "red-rust" stage; *B*, spores germinating and penetrating the plant; *C*, late spores or "black-rust" stage. *After Ferguson and Lewis.*

and the plant from which it gets its food is called the *host*. When the spore of a destructive fungus lodges on a plant under conditions favorable to its development, it sends out threadlike growths which pierce the epidermis of the plant. A common mode of entrance is through the stomata. This filament continues developing and dividing within the plant, and may extend a long distance from the point of entrance. These growths that enter the plant are not roots of the fungus, but are the fungus itself. Extending thus among and into the cells the fungus feeds on the plant. The cells may break down and the plant wither as a result of this

* Plants that live on dead plants or disintegrating plant matter are called *saprophytes* (săp′rō phīts).

attack, or an abnormal growth may take place, producing the galls and warts which we so often see on infected plants. Soon the fungus develops a crop of spores, which with them take the place of seeds, as you know. These being microscopically small, and very numerous, are easily blown about by the wind and carried by insects to other parts of the plant, and to other plants, with the result that soon the disease is scattered over the field. It is the enormous number of the spores of fungi, the rapidity with which they are developed, and the ease with which they are carried about that cause fungus diseases to play such havoc. In addition to the ordinary spores which spread the disease during the growing season, many fungi produce an extra-tough type of spore about the end of the growing period that can live through the long dormant season and start the trouble again the next year. The appearance of red rust of the wheat, for example, is due to the countless red spores produced during the growing season, while the black-rust stage is due to the tougher kind of spores that develop later and can survive till the next season. These diseases are made more

Fig. 172. Peach mummy caused by brown rot.

difficult to get rid of by the fact that many of them may live also on weeds and other vegetation besides the cultivated crops, as the apple rust lives on cedar-trees, where it causes the cedar-balls. From such places these disease-producing fungi are carried back to the cultivated crops.

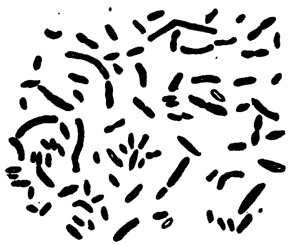

FIG. 173. The bacteria that cause pear blight.—*After Warren.*

Bacteria are, as you know, one-celled plants that multiply by dividing, just as the cells do in the cambium layer. The disease-producing bacteria, when once they are successfully lodged on or within a plant, multiply with enormous rapidity and are blown about the field by the wind or carried by insects and birds from infected to sound plants. The bacteria frequently find a lodgement more easily when they fall on a cut or bruised surface, or upon blossoms or very tender buds, as is the case with the bacterium causing pear blight.

FIG. 174. Spores of brown rot of peach.—*After Warren.*

248. **How to Control Plant Diseases.**—Nowhere is it more true that "an ounce of prevention is worth a pound of cure" than in the handling of plant diseases. When once the fungus or bacterium is within the tissue of the plant, there is no successful way known of reaching it. Then all that can be done is to prevent the further spread by spraying, and by cutting off and burning diseased parts, or even an entire tree or crop.

While sprays will not destroy the fungi that are within the plant, they destroy those on the surface with which they come in contact. If all exposed surfaces are sprayed the new spores that find lodgement come in contact with the poison, and are killed before they can develop enough to enter the plant. These substances that kill fungi, but do not destroy the host plant, are called *fungicides* (fŭn′jĭ-sīdz). The most common fungicide is *Bordeaux* (bôr′dō) *mixture*, the formula for which you will find farther on in this chapter. If fungicides are to be of much value, the plants must be thoroughly covered, and the spraying must begin before the spores left from the past season have begun to germinate, and before the new crop of spores is formed. If fungicides are applied thoroughly and repeated at the right times, most plant diseases that affect the parts exposed to the air may be controlled.

Fig. 175. Potato infected with scab on left, sound potato on right.

For those diseases that affect the roots, or find entrance through the roots, such as cotton wilt and club root of cabbage, spraying will not avail. With the underground diseases the first precaution to take is to see that the fungi or bacteria that may be on the seeds are destroyed before planting the crop, as the potato scab is destroyed by soaking the potato in a solution of formalin. When once the land is infected, then rotation should be practised, and for several

years no crop on which that fungus or bacterium can live should be grown on this land. In this way they may usually be destroyed. Cultural methods also are often a great

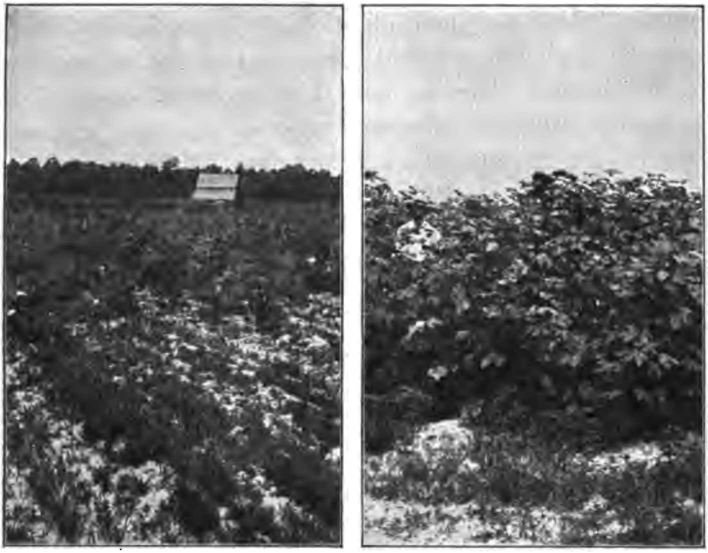

FIG. 176. Ordinary cotton on the left and Dillon wilt resistant cotton on right, grown in adjoining fields, the soil on the right being worse infected than that on the left, but making no impression on the resistant cotton.
Courtesy of U. S. Department of Agriculture.

aid. Damp soil favors the growth of most injurious soil fungi, and air and sunshine hurt them. Drainage and thorough tillage, opening up and getting air into the soil, help to purify it. Occasionally the application of lime will be helpful. In very limited areas, such as the germinating bed used for tobacco, sterilization of infected soil by "live" steam has been successfully employed.

249. **Disease-Resistant Varieties of Plants.**—For reasons difficult to explain, certain plants are able to resist successfully the attacks of a disease that destroys other plants of the same variety growing around them. By selection of the resistant plant and multiplication, it is possible in many cases to develop a resistant variety which will be immune to this disease. This has been done in several cases. The rust-proof oats, the wilt-proof varieties of cotton, and the Iron peas, that resist wilt, are examples. Right here is one of the most valuable fields of work for the thoughtful farmer boy and girl. Wherever an insect or disease has attacked a field, a careful search should be made for individual plants that have successfully withstood the attack. The seeds of these should be saved, and planted again where the plants will be exposed to attack. Each year the non-immune plants should be destroyed and seed saved only from those that are immune. In this way a variety may be developed that is wholly or practically immune.

Insecticides and Fungicides.

250. **Formulas Vary With the Conditions.**—Different conditions of climate and different plants demand different sprays or different strengths of the same spray, even when fighting the same pest. Here only general directions can be given. Before undertaking any large and important spraying work, the experts of the State Department of Agriculture, of the Agricultural and Mechanical College, or of the University should be consulted.

The poisons usually employed as insecticides are *Paris green* and *arsenate of lead*, both deadly poisonous compounds of arsenic. The arsenate of lead is not injurious to foliage. The usual formula for preparing the solution is:

ARSENATE OF LEAD

Arsenate of lead	$2\frac{1}{2}$ lbs.
Water	50 gallons

Dissolve the arsenate in a small quantity of water, then strain into the remainder of the water. The powdered arsenate gives the best results.

Paris green often injures foliage if used alone or in too strong a solution. It is therefore mixed with lime and water in different proportions, depending upon the use to which it is to be applied. When applied dry it is mixed ten to forty parts of lime to one of Paris green. For use on orchard trees and shrubs the usual formula is:

PARIS GREEN

Paris green	$\frac{1}{3}$ lb.
Lime	1 lb.
Water	50 gallons

First make a paste with the Paris green and a little water, then dissolve this and the lime in a small quantity of water, and strain into the remainder of the water. For potatoes and for poisoning weeds and trap crops where there is no danger of injury to the foliage, three times this amount of Paris green and lime is used to the same quantity of water.

For poisoning grasshoppers while crossing bare places, or cutworms and other insects in early spring, or when the vegetation has been removed from a spot, a poisoned bran mash is made as follows:

POISONED BRAN MASH

Wheat bran	25 lbs.
White arsenic	1 lb.
Molasses	2 quarts

Mix the bran and arsenic, dilute the molasses with two quarts of warm water, pour this into the vessel containing the bran and arsenic, and mix thoroughly. Add water enough to make a stiff mash.

The most common fungicide is *copper sulphate.* As this injures foliage if applied alone, it is generally used in a combination with lime and water, called *Bordeaux mixture.* For tough foliage, like that of the potato, six pounds of lime and six of copper sulphate to fifty gallons of water are used; for apples and pears, three or four pounds each; for tender foliage, two pounds of each to fifty gallons of water.

BORDEAUX MIXTURE

Copper sulphate	2 to 6 lbs.
Lime	an equal quantity
Water	50 gallons

If strong solutions of lime and copper sulphate are put together they form a thick, curdled mass hard to mix when more water is added. For that reason care must be taken in preparing Bordeaux mixture. Dissolve the sulphate and the lime in separate vessels in several gallons of water each, then either add half the remaining water to each vessel, stirring well, and then mix the two, or add practically all the water to one vessel, and pour the other solution into this, stirring well all the while. It is usually best to tie the copper sulphate in a sack and suspend it in the water, and also to put the lime and water together the day before the mixture is to be made.

A combined insecticide and fungicide is often used, which is made by adding either arsenate of lead or Paris green to the Bordeaux mixture. The arsenate is generally used, two and one-half pounds being added to the fifty gallons of Bordeaux mixture prepared as shown above.

The several contact remedies are prepared as follows:

LIME-SULPHUR SPRAY

Lime	20 lbs.
Sulphur	16 lbs.
Water	50 gallons

Mix the sulphur and a little of the water into a paste, add about fifteen gallons of the water boiling hot, then add the lime and stir thoroughly. Boil this about an hour, until the bright yellow color disappears and the mixture becomes rich amber. Then add the remainder of the water. This is used especially for San José scale and other scales. It should be used while the tree is dormant, as a solution strong enough to destroy the scale injures foliage. This also is injurious to eggs that have survived the winter, such as those of aphides, and pupæ, such as those of the pecan-bud worm. It is also a good fungicide, being used often with dormant trees in place of Bordeaux mixture.

For the control of brown rot in peaches and on foliage this mixture is used:

SELF-BOILED LIME-SULPHUR SPRAY

Sulphur	8 lbs.
Fresh stone lime	8 lbs.
Arsenate of lead	2½ lbs.
Water	50 gallons

Place the lime in a barrel with enough water to cover it. As soon as it begins to slake add the sulphur, running it through a sieve. Stir constantly and slowly add water. When well slaked and in a thin paste add the remainder of the water. The arsenate should be mixed into a paste and dissolved in a small quantity of water before being added to the mixture. The whole should be strained.

For sucking insects, such as plant-lice, leaf-hoppers, young squash and harlequin-bugs, and nearly all other insects not controlled by the above-described mixtures, kerosene emulsion is used with good effect.

KEROSENE EMULSION

Whale-oil or laundry soap	½ lb.
Boiling soft water	1 gallon
Kerosene	2 gallons

Dissolve the soap in the boiling water, take away from the fire, and add the kerosene. Churn or pump this mixture with a spray pump till it is thoroughly emulsified (ē-mŭl′sĭ-fīd). It will be increased in bulk noticeably, and have a creamy consistency when well emulsified. For use on dormant trees or hard-bodied insects, dilute this with eight to ten gallons of water; on foliage and soft-bodied insects, use fifteen to twenty gallons of water.

For scales, plant-lice, mites, and thrips the following is effective:

WHALE-OIL SOAP EMULSION

Whale-oil soap	1 lb.
Water	6 gallons

As a repellent on cucumber and young melon vines to the cucumber beetles and similar insects, *hydrated lime* is effective. This should be dusted on thoroughly.

In poultry-houses and barns, and on vegetation that is affected with mites or spiders, *sulphur* copiously applied is effective. A solution of one ounce to a gallon of water is used commonly for mites and red spiders.

The poisons for biting insects need not be so thoroughly applied, but all contact poisons affect only those insects or

SPRAY CALENDAR

INSECT OR DISEASE	WHEN TO SPRAY	WITH WHAT TO SPRAY
All scale insects.	Early spring, before buds swell.	Lime-sulphur spray. (During growing season, use oil or soap spray.)
Striped melon-beetles.	When the young plants appear above ground.	Tobacco dust or hydrated lime.
All leaf-eating insects.	When insects appear.	Arsenate of lead, Paris green, or other arsenical poison.
All sucking insects, such as plant-lice.	When insects appear.	Kerosene emulsion or whale-oil soap.
Fruit rot.	Before blossoms open, and repeat till crop is safe.	Bordeaux mixture or self-boiled lime-sulphur spray.
Mildews and black rot of grapes.	Before blossoms open, when leaves are one-third grown, just after fruit sets, and every two weeks thereafter.	Bordeaux mixture.
Codling moth.	Just after blossoms fall, and again later.	Arsenical mixture.
Leaf-curl.	Before buds swell, and later.	Bordeaux mixture, or self-boiled lime-sulphur spray.
Mites and spiders.	When they appear.	Sulphur.
Potato scab.	Before planting.	Formalin, 1 oz. to 2 gals. water.
Grain smut.	Before planting.	Formalin, 1 oz. to 3 gals. water.

fungi with which they come into direct contact, so that absolute thoroughness in spraying is essential to success. Every fungus or insect left untouched serves to start a new generation.

For destroying insects injurious to stored grain and other farm products, *carbon bisulphide,* or "high life," as it is often called, is used in the following way: Place the bisulphide in a vessel on top of the material to be treated and cover the pile with blankets or tarpaulin. The bisulphide gives off poisonous fumes that are heavier than air and pour down into the pile. The whole must be kept tightly inclosed for twenty-four hours. If a tight box can be used, the cloth cover may be left off. In cold weather the vessel may be set upon a warm brick, but no fire (not even a lighted pipe) should be brought near it, as the gas is exceedingly explosive. The fumes are poisonous, and hence should not be breathed. Use one pound to every thousand cubic feet of space to be fumigated. In fumigating grain, from one to three pounds per hundred bushels are used.

In order to destroy an ant bed, pour three ounces of the bisulphide into a shallow pan and set beside the entrance to the bed. Invert a tub over the pan and the entrance to the bed, and pile soil around the bottom of the tub to prevent the escape of the gas to the air, and force it all down into the bed. Close all other entrances to the bed with soil and leave for twenty-four hours. This is more effective if applied while the earth is moist and warm.

To prevent oat smut, concealed smut of wheat, and scab of Irish potato, *formalin* is used. Grain is moistened in a solution of one ounce of formalin to three gallons of water and kept moist for two hours, after which it is dried. Care

must be taken that it is not allowed to come in contact with smut again before being planted. Potatoes used for seed should be soaked for two hours in a solution of one ounce of formalin to two gallons of water in order to kill the scab.

251. **Caution—Danger.**—As arsenic, asenate of lead, Paris green, carbon bisulphide, formalin, and most other insecticides and fungicides are poisons, they should be handled with care, always labelled, and never left in reach of children, stock, poultry, or other animals.

QUESTIONS, PROBLEMS, AND EXERCISES

147. Make a list of the harmful insects in your neighborhood, and collect a set of bulletins that deal with these.
148. Collect two varieties of biting insects. Draw and describe each.
149. Collect two varieties of sucking insects. Draw and describe each.
150. Place the eggs of some insect in such a cage as is shown in Figure 155, and make notes from day to day of the development. Watch some insect and, if possible, get eggs just as they are laid. Be sure to give the larvæ plenty of fresh food.
151. Make a list of the birds of your neighborhood. Find from the references what each one lives on at each season of the year. If you have a common bird the food of which is not given in the references, kill a few at different times of the day and seasons of the year, and make a note each time of the contents of the craws.
152. Find all of the kinds of helpful insects in your community. Bring some of each of these for the school garden.
153. If any insect or disease has afflicted your father's farm, study this pest in the references, write out a practical plan for combating it. Show this to the teacher and, when it is approved, carry it out and report results.
154. What fungus plant diseases are in your community? How should each be treated?
155. What bacterial plant diseases are in your community? How should each be treated?

156. What plant diseases in your community are due to infected soil? How could this be remedied?
157. Find out any cases of loss from insects in your neighborhood and, with the help of the teacher, calculate the amount this insect costs your county.
158. Find an orchard or yard affected with scale. Secure permission to treat it and, with the teacher's help, plan and carry out a treatment.
159. Keep a lookout for some immune plant in a crop that has been destroyed by some insect or disease. Save seeds and see if you can breed a resistant variety.

REFERENCES FOR FURTHER READING

"Diseases of Economic Plants," Stevens and Hall.
"Insect Pests of Farm, Garden and Orchard," Sanderson and Peairs.
"Insects and Insecticides," C. M. Weed.
"Fungous Diseases of Plants," B. M. Duggar.

Farmers' Bulletins:

No. 279. "Method of Eradicating Johnson Grass."
No. 606. "Collection and Preservation of Insects and Other Materials for Use in the Study of Agriculture."
No. 650. "San Jose Scale and Its Control."
No. 657. "Chinch Bug."
No. 660. "Weeds: How to Control Them."
No. 662. "Apple-tree Tent Caterpillar."
No. 670. "Field Mice as Farm and Orchard Pests."
No. 702. "Cottontail Rabbits in Relation to Trees and Farm Crops."
No. 725. "Wire Worms Destructive to Cereal and Forage Crops, with Control Measures."
No. 739. "Cut Worms and Their Control in Corn and Other Crops."
No. 747. "Grasshoppers and Their Control in Relation to Cereal and Forage Crops."
No. 766. "The Common Cabbage Worm."
No. 832. "Trapping Moles and Utilizing Their Skins."

No. 843. "Important Pecan Insects and Their Control."
No. 856. "Control of Diseases and Insect Enemies of the Home Vegetable Garden."
No. 868. "Increasing the Potato Crop by Spraying."
No. 872. "The Bollworm or Corn Ear Worm."
No. 890. "How Insects affect the Cotton Plant and Means of Combatting them."
No. 896. "Rats and Mice."
No. 915. "How to Reduce Weevil Waste in Southern Corn."
No. 925. "Cabbage Diseases."
No. 932. "Rodent Pests on the Farm."
No. 933. "Spraying for Control of Insects and Mites Attacking Citrus Trees in Florida."
No. 945. "Eradication of Bermuda Grass."
No. 950. "The Southern Corn Root Worm and Farm Practice to Control It."
No. 1029. "Conserving Corn from Weevils in the Gulf Coast States."
No. 1038. "The Striped Cucumber Beetle and Its Control."
No. 1041. "Eelworm Disease of Wheat and Its Control."
No. 1061. "Harlequin Cabbage Bug and Its Control."
No. 1083. "The Hessian Fly."
No. 1086. "Insects Affecting the Rice Crop."
No. 1102. "The Crow in Its Relation to Agriculture."
No. 1166. "Poison Ivy and Poison Sumach and Their Eradication."
No. 1169. "Insects Injurious to Deciduous Shade Trees and Their Control."
No. 1217. "The Green Bug or Spring Grain Aphis."
No. 1220. "Insect and Fungous Enemies of the Grape."
No. 1246. "The Peach Borer: How to Prevent or Lessen Its Ravages."
No. 1260. "Stored Grain Pests."
No. 1262. "The Boll-Weevil Problem."

Bulletins, Texas Agricultural Experiment Station, College Station, Texas:

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No. 187. "Sprays and Spraying."

Bulletin of Texas State Department of Agriculture:
No. 60. "The Control of Destructive Animals."

The A. and M. College, of Texas, Farm and Home Hints:
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"Ant Control."
"Rodent Pests."
"Boll Weevil Control Measures Practicable in Fall and Winter."

CHAPTER XII

ANIMAL HUSBANDRY AND CATTLE

252. **The First Reason for Raising Stock on the Farm.**—We have already seen that heavy crops take out of the soil large quantities of the food materials necessary for plant growth, and that unless these are put back into the soil the land will soon become too poor to produce a good crop. We have also seen that when the crop is fed to animals and the manure properly saved and put back into the soil, between eighty and ninety per cent of the valuable plant-food materials are thus returned. On the other hand, if the crop is sold and carried off the farm, the farmer must constantly purchase large quantities of expensive fertilizers or his fields will soon not repay him for the labor of cultivating them. This is why the thoughtful farmer should always raise enough live-stock to eat practically all the foodstuffs produced on his farm. By feeding his crops to stock and then selling the stock, he retains at home in the manure nearly nine-tenths of the value of his crop, and sells the animals for as much as, often for more than, he could have sold the crop.

253. **Other Reasons for Raising Stock.**—Besides this there are seven other advantages that in most cases come from raising stock on the farm instead of raising only cotton, grain, and other plant crops. First, the raising of some live-stock necessitates the growing of hay, clover, alfalfa, peas, pea-nuts, and other cover crops and legumes which add

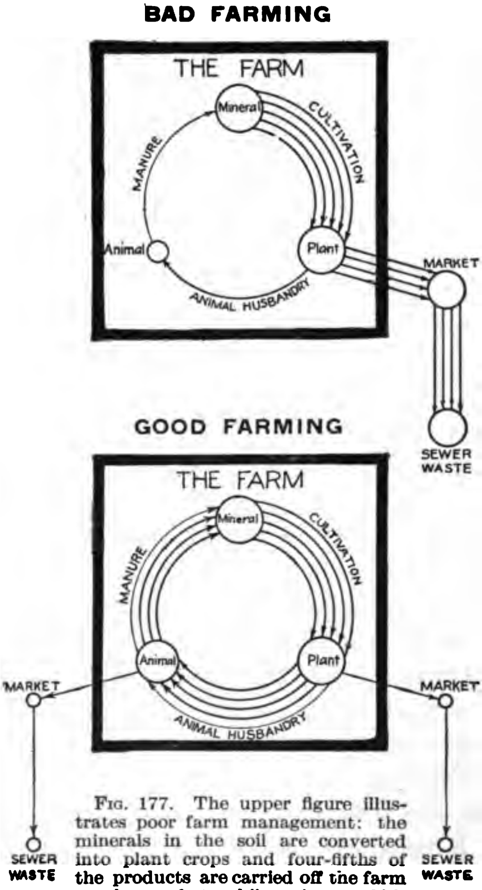

Fig. 177. The upper figure illustrates poor farm management: the minerals in the soil are converted into plant crops and four-fifths of the products are carried off the farm to the market, while only one-fifth is fed to stock and thus left on the farm in the form of manure. The lower figure illustrates good farm management: the same minerals in the soil are converted into plant crops, but only one-tenth of these is taken off the farm to market, the other nine-tenths are fed to stock. The stock leave on the farm in their manure seven-tenths of the minerals that were taken from the soil and carry away only two-tenths when they are sold in the market.

humus, and in some cases nitrogen, to the soil. This diversifying the crops also makes farming more certain, as then no one failure due to unfavorable season or insect pest can affect all the crops of any one year. Second, this diversification and the stock-feeding distribute the labor of the farm more evenly through the year, instead of causing great rushes at special seasons. A good part of the work of feeding stock for market comes in late fall and winter when the crops are out of the way. Third, there are always

remnants of crops and a great deal of grass left in fields that can be gathered at no expense by animals and converted into salable meat. Fourth, a considerable part of the expense of harvesting and of hauling out fertilizer is saved with many crops by turning into the field the stock, which do their own harvesting and drop the manure in the field. Fifth, when several thousand pounds of crops are fed to stock, there are only a few animals to be driven to market instead of the several thousand pounds of produce to be hauled. This saves time and teams. Sixth, in most cases, except where markets are very near or the soil and climate are especially adapted to some particular crop, more money can be made by devoting a considerable part of the farm to raising stock and the crops that feed stock economically than can be made by raising all market crops such as cotton. Seventh, the raising of stock makes farming more interesting and attractive to both old and young, and broadens the thinking of the farmer. It is therefore perfectly plain that except under very special circumstances every farmer should raise at least enough live-stock to consume all the food crops that a well-planned rotation, including legumes and winter cover crops, would demand on his farm.

254. **Texas Especially Adapted to Stock-Raising.**—Texas is especially adapted to stock-raising. The mild winters and long growing season make it possible to have green food in the field all the year, and to allow the stock to exercise and to gather their own feed in large part nearly all the time. Such expensive barns and long winter feeding as are demanded in the North are not required, nor are the dangers of diseases caused by close housing so great. Furthermore, such a large part of the food eaten does not have to be used by the animal

in keeping warm. With her vast acres of pasture land and mild climate, Texas should develop her stock-raising rapidly, now that practical methods of handling the cattle tick and other animal pests and diseases have been learned.

255. **The Loss From Raising Scrub Stock.**—The cattle tick, through interfering with the bringing of finer pure-bred stock into the Southwest, has cost and is costing this section tens of millions of dollars a year. Texas in 1910 had 7,131,000 beef cattle. This was about twice as many as any other State had, Iowa, the State with the next largest number, having only 3,611,000. The Texas cattle, however, were valued at only $15.30 her head, while those in Illinois and Wyoming were valued at $26.40, and those in Montana at $27.40. If Texas beef cattle were raised to the same quality as those of Montana, $86,000,000 would be added to the wealth of the State. In 1910 Texas had 1,137,000 dairy cattle, valued at only $25.50 apiece, while New Jersey dairy cattle were valued at $47.50 a head. If Texas dairy cattle were raised to the same quality as those of New Jersey, over $25,000,000 would be added to the State's wealth. It takes nearly as much labor and feed to raise a scrub as it does to raise a pure-bred or high-grade animal. The raising of scrub stock is therefore very wasteful and unintelligent. In former years, when there were millions of acres of cheap land, it was possible to make a profit from scrub stock turned out to graze with very little oversight. Now, with higher-priced land and the country rapidly being broken up into small farms and ranches, the ranchman and farmer can no longer afford to waste time and food on scrub stock. When Herefords and Shorthorns will weigh two thousand pounds, it is poor economy to raise scrubs that weigh one thousand

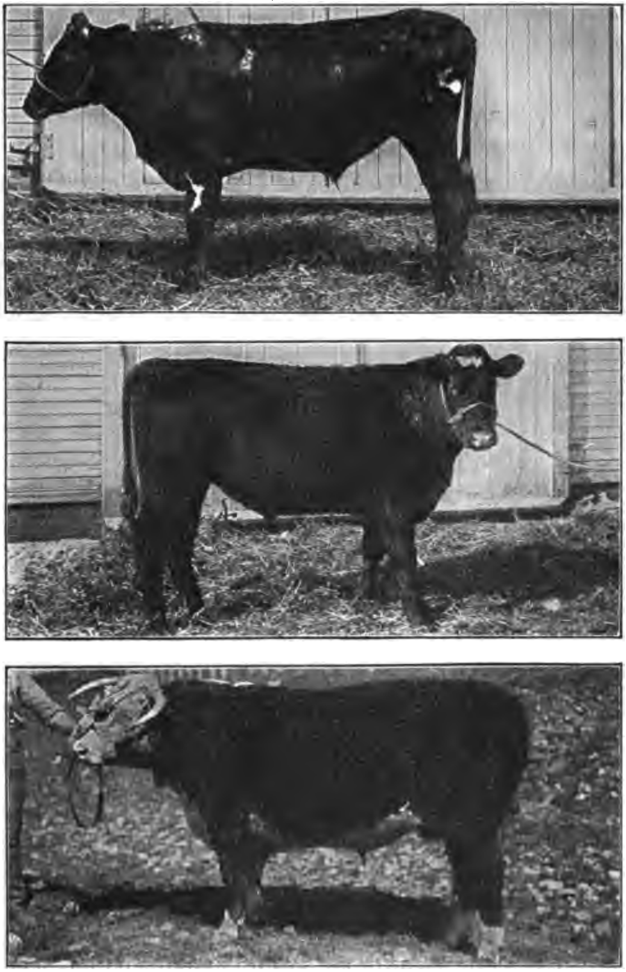

FIG. 178. Above, an inferior feeder; in the centre, a choice feeder; below, a fat steer of the correct type.

Courtesy of the Agricultural and Mechanical College of Texas.

or less. When Jerseys or *Holsteins* (Hōl′stīnz) will produce from five hundred to over a thousand pounds of butter a year, is it sensible to feed milk cows that produce only a hundred and fifty pounds per year?

256. **How to Improve the Quality of Stock.**—While it is not practicable for all farmers at once to buy and raise only pure-bred stock, it is practicable to grade rapidly a herd at small expense by breeding only from pure-bred males. As you know, the parents of a scrub do not belong to any particular breed, but are a mixture of many inferior types, whereas both parents of a pure-bred belong to the same breed of selected stock. The result of this is that when a pure-bred male is crossed on a scrub female, the offspring, which is called a *grade*, is more likely to resemble the pure-bred male parent than the scrub female. For example, if a pure-bred Hereford bull is used, nearly all the calves will show the fine Hereford qualities. None of the males of these *half-bloods*, as the offspring of a full blood and a scrub are called, should be allowed to breed. The female half-bloods should be crossed again with a pure-bred and thus secure a three-quarter pure grade. These similarly being crossed with a full-blooded bull will produce calves that are seven-eighths pure, or *high grade*. For practical beef and dairy purposes, such high grades are nearly as good as pure-breds, but they would not bring high prices for breeding purposes. Grade bulls should not be used for breeding, as with a mixed ancestry the calves from them would not be apt to come true. As long as the grade females are always bred to a pure-bred bull, however, the calves are very apt to possess the qualities of the good stock.

257. **What Must Be Known to Get Highest Profit From Stock-Raising.**—In order to get the greatest profit from his stock-raising the farmer must know two things: First, what kinds of animals and animal products—meat, milk, butter, wool, and eggs—the market demands and pays best for; second, how to produce these at the least cost. In order to produce at the least expense animals that will bring the highest prices, three things must be learned. These are: First, live-stock judging; second, live-stock breeding; third, live-stock feeding. Let us now study each of these.

258. **Live-Stock Judging.**—Live-stock judging is the basis of all success in stock-raising. If one does not know what are desirable points in an animal he will not know how much to pay for animals that he buys, nor what to charge for those that he sells, nor will he know which animals to select and breed from in his herd. One horse sells for $500, while another that looks very much like it to the untrained observer brings only $150. One bull sells for $50, while another that does not look very different to the average boy sells for $500. Let us take up the several farm animals in turn and find out what points are important and what relative value should be given to each different quality.

CATTLE

259. **Classes of Cattle.**—Cattle are divided into three classes: *beef cattle,* or those raised for beef; *dairy cattle,* or those raised for their milk and butter; *dual-purpose cattle,* or those raised both for beef and for milk and butter. Each of these classes has its special points which have definite values in estimating the quality of the animal judged. These can be learned thoroughly only by study of actual cattle with the

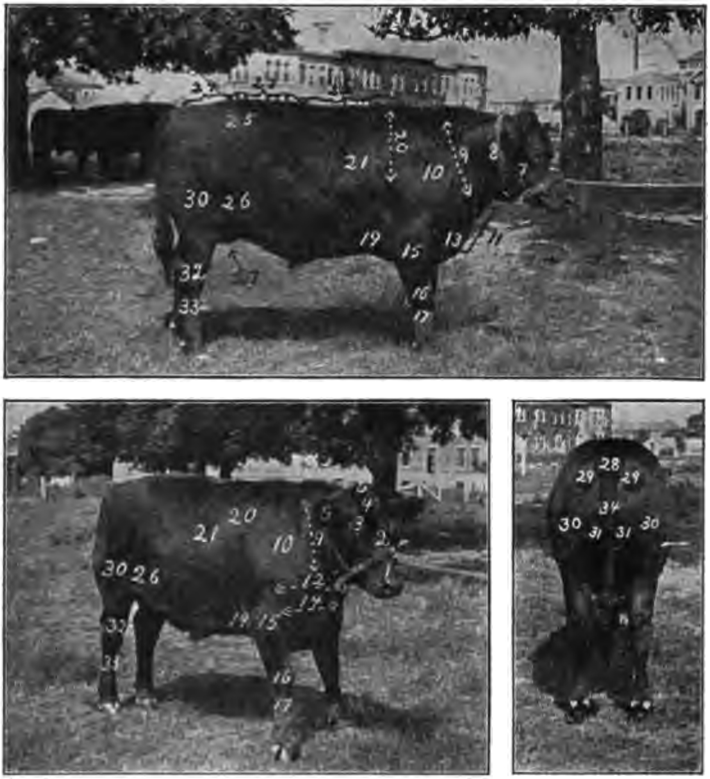

Fig. 179. Points of the beef animal: 1, muzzle; 2, face; 3, eyes; 4, forehead; 5, ears; 6, poll; 7, jaw; 8, neck; 9, shoulder vein; 10, shoulder; 11, dewlap; 12, chest; 13, brisket; 14, breast; 15, arm; 16, knee; 17, shin; 18, hoof; 19, fore-flank; 20, crops; 21, ribs; 22, back; 23, loin; 24, rump; 25, hips, or hooks; 26, hind-flank; 27, purse, or cod; 28, tail-head; 29, pin bones; 30, thigh; 31, twists; 32, hocks; 33, shank; 34, tail.

Courtesy of the Agricultural and Mechanical College of Texas.

aid of a trained judge, but with the aid of pictures and the following descriptions any boy or girl may make a good start in learning to judge cattle.

260. **Beef Cattle.**—Beef cattle are divided into: (1) "fat steers," meaning those ready for the butcher; (2) "feeders," meaning those that are ready to be fattened for the butcher; and (3) "breeding cattle," meaning those used for breeding purposes.

The *fat steer* for which the butcher pays the highest price is one that will dress out the highest per cent of salable meat and that carries the maximum amount of this meat in the regions from which the most valuable cuts come. In order to meet these requirements the fat steer must have a broad, deep, low-set, smooth, compact form with straight top and under lines. He must show especially high development in the ribs, loin, rump, and thighs, which are the regions of the high-priced cuts. He must possess good quality, as indicated by fine, soft hair, loose, pliable skin of medium thickness, even, firm, mellow flesh, and clean, medium-sized, dense bone. He must be in good condition, as indicated by a deep, even covering of firm flesh, especially in the region of choice cuts. The scrub steer with swayed back, high flanks, narrow, shallow body, long legs, probably large paunch, coarse bone, thick hide, coarse hair, and thin covering of flesh not only dresses out a low per cent of salable meat, but too large a proportion of this meat is located in the regions of the low-priced cuts. Figures 178, 179, 180 will make this description clear.

The score-card on the next page presents the points in detail to be considered in judging fat cattle and shows the relative value of those points. The score-card is of great aid to the beginner in stock-judging, in familiarizing him with the ideal type, in enabling him to distinguish clearly and fix in memory the points to be observed, and to judge in a system-

SCORE-CARD

From Circular No. 29, Purdue University

BEEF CATTLE **FAT**

SCALE OF POINTS	STANDARD	POINTS DEFICIENT: STUDENT'S SCORE	POINTS DEFICIENT: CORRECTED
GENERAL APPEARANCE—40 PER CENT			
1. WEIGHT, estimated......lbs. Actual......lbs. according to age..........................	10	......	......
2. FORM, straight top and underline; deep, broad, low set, stylish, smooth, compact, symmetrical	10	......	......
3. QUALITY, fine, soft hair; loose, pliable skin of medium thickness; dense, clean, medium-sized bone..............................	8	......	......
4. CONDITION, deep, even covering of firm, mellow flesh; free from patches, ties, lumps, and rolls; full cod and flank indicating finish....	12	......	......
HEAD AND NECK—7 PER CENT			
5. MUZZLE, broad; mouth large; nostrils large and open................................	1	......	......
6. EYES, large, clear, placid....................	1	......	......
7. FACE, short; jaw strong....................	1	......	......
8. FOREHEAD, broad, full......................	1	......	......
9. EARS, medium size; fine texture.............	1	......	......
10. NECK, short, thick, blending smoothly with shoulder; throat clean, with light dewlap.....	2	......	......
FORE-QUARTERS—9 PER CENT			
11. SHOULDER VEIN, full.......................	1	......	......
12. SHOULDERS, smoothly covered, compact, snug, neat....................................	4	......	......
13. BRISKET, trim, neat; breast full..............	2	......	......
14. LEGS, wide apart, straight, short; arm full; shank fine	2	......	......
BODY—30 PER CENT			
15. CHEST, full, deep, wide; girth large; crops full..	4	......	......
16. RIBS, long, arched, thickly and smoothly fleshed..................................	8	......	......
17. BACK, broad, straight, thickly and smoothly fleshed..................................	8	......	......
18. LOIN, thick, broad..........................	8	......	......
19. FLANK, full, even with underline............	2	......	......
HIND-QUARTERS—14 PER CENT			
20. HIPS, smooth...............................	1	......	......
21. RUMP, long, wide, level; tail-head smooth; pin bones wide apart, not prominent...........	3	......	......
22. THIGHS, deep, full.........................	4	......	......
23. TWIST, deep, plump.........................	4	......	......
24. LEGS, wide apart, straight, short; shanks fine, smooth..................................	2	......	......
Total..................................	100	......	......

atic way. As soon as these purposes are accomplished, further use of the card is not necessary. The student should then be able to judge and criticise an animal without referring to the

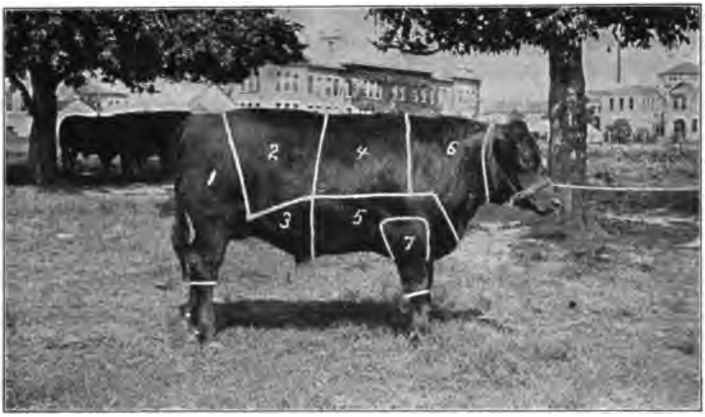

Fig. 180. Wholesale cuts on a steer: 1, round; 2, loin; 3, flank; 4, rib; 5, plate; 6, chuck; 7, shank.
Courtesy of the Agricultural and Mechanical College of Texas.

card. After becoming proficient in judging a single animal, comparative judgments of two or more animals may be made.

The feeder steer is the one not yet fat but ready to be fattened for the market. The ideal feeder is one that will make the most economical gains in the feed lot and will when fat meet the ideal of the fat steer. The difference between the ideal feeder and the ideal fat steer is a matter of condition, or flesh covering. The most important points to be considered in feeders are the following. The body should be deep and wide, the top and bottom lines straight, legs short, and general appearance smooth and compact. The depth and thickness are not, of course, as great in the feeder as in the

fat steer, but the more pronounced they are in the feeder the greater they are likely to be in the fat steer. A wide back, well-sprung ribs, wide, thick loin, level, long, wide rump, giving squareness to the hind-quarters, thickly fleshed thighs, and deep twist are demanded to make sure of large valuable cuts when the animal is fat. The skin should be loose, pliable, and of medium thickness; the hair soft and glossy; the bone clean, dense, and of medium size. Medium-sized bone is preferred to small bone, because it has been found that animals possessing medium-sized bone have better constitutions and when fed give larger return than do those with small bones. The loose, pliable skin and the glossy hair indicate good digestion, which is essential to economical gains in the feed lot. While not fat, the feeder must possess a large amount of flesh or lean muscular tissue, otherwise it will not dress out a large per cent of good quality of meat when fat. The feeder should have a strong constitution, as is indicated by deep, wide chest, large nostrils, large muzzle and mouth, bright, clear, quiet eyes, short, broad head, well-arched deep ribs and low flanks, giving large capacity for food. The butcher does not care for large head or large paunch, but in the feeder they are desirable, as they indicate ability to make good use of food and make rapid gains in the feed lot.

Breeding cattle when thin should represent ideal feeders and when fat ideal fat cattle; but in addition to this they should possess qualities which indicate that they will breed regularly and that the offspring will resemble their parents. No matter how good the animals may be as individual specimens, they will not do as breeders unless they can reproduce their kind with regularity. The following points should be looked for in breeders.

1. The animal should be true to his type; that is, the Hereford should have the characteristics of the Hereford and the Jersey of the Jersey. The distinguishing features of each type have been fixed in it by long years of carefully breeding only animals of this type. Those that are good representatives of the type are therefore more apt to be able to transmit this type to their offspring than would a specimen that had varied from the type. An animal capable of doing this is spoken of as *prepotent*.

2. The animal should possess the characteristics of the sex to which it belongs. Such animals are more apt to be prepotent. The bull should show the following masculine characteristics: bold expression in eyes; full forehead; thick neck, surmounted by heavy, well-developed crest; heavy, though not coarse, shoulders, giving him a strong, vigorous, burly appearance. The female should show the following feminine characteristics: mild expression in eyes, refinement of head and horns, neck slender and shoulders light as compared with the bull, more width and prominence of hips than the bull, and a generally gentle appearance.

3. The constitution must be strong, as only animals having such can stand the strain of producing offspring regularly and at the same time transmit to the offspring their strength and vigor. The signs of a strong constitution you have just learned in studying the feeders.

261. **Breeds of Beef Cattle.**—There are eight breeds of beef cattle recognized in the United States: *Shorthorn, Hereford, Aberdeen-Angus, Galloway, Polled Durham, Polled Hereford, Sussex,* and *West Highland.* The first four are considered the principal breeds. Only the first three have gained prominence in Texas.

The Shorthorn. This breed originated in England, probably from the old Teeswater and Holderness stock, in the counties of York, Durham, and Northumberland. Shorthorns are sometimes improperly called Durhams. As early as 1780 the special selection and breeding were begun which

FIG. 181. A Shorthorn bull.
Courtesy of the Agricultural and Mechanical College of Texas.

produced this remarkable beef type, possessing easy-feeding qualities, early maturity, and thick flesh of good quality. The breed has long been prominent and steadily improved. In size the Shorthorn ranks first, bulls at maturity weighing two thousand to twenty-two hundred pounds. Many weigh as high as twenty-five hundred pounds. Cows weigh fourteen hundred to sixteen hundred pounds, some as high as two thousand pounds. The color may be pure red, pure white, red and white spotted, or roan, which is a mixture of red and white. The breed is sometimes called the "reds, whites, and roans." The horn, which is a well-marked

characteristic of the breed, is usually short and small, preferably curved forward, with the tips bending inward and upward. The breed is noted for wide back, strong loin, and square, well-developed hind-quarters. It is criticised because of length of legs and lack of heart girth, as shown by insufficient fulness back of shoulders, in the *crops* and fore-flanks. As milk producers they rank first among the beef breeds.

The Shorthorn is especially adapted to the farm, but not so well adapted to range conditions, particularly where exposed to severe winters, as the Hereford. Shorthorn bulls are used on the ranches, however, by many cattlemen because of the marked improvement produced in the size of the stock.

The Hereford is a native of Hereford County, England, the breed having originated early in the eighteenth century in efforts to produce a breed better suited to the production of fine beef by grazing. The Hereford is shorter of leg and somewhat more compact in appearance than the Shorthorn, but weighs practically as much. The color is remarkably uniform; the face, breast, top of neck, legs usually from slightly below the knee and hock down, the belly, and switch of tail are all white. The rest of the body is red. The breed is often called the "white face." The head is shorter and broader than that of the Shorthorn, the horns longer and keener toward the tips. The horns are white or waxy yellow, and spring forward and usually down with a graceful curve. The Hereford is especially noted for its excellent constitution, thick middle, beautiful front, and early maturity. The most common defect in the form is light hindquarters, owing to a drooping, peaked rump and poorly

developed thighs. The American breeders especially have in recent years greatly improved this breed in this respect. Hereford cows rank very low as milk producers.

Many Herefords have been imported and, because of the

FIG. 182. Druid of Point Comfort, grand champion Hereford bull 1908–1912. *Courtesy of Lee Brothers.*

excellent grazing qualities and adaptation to ranches, have been distributed rapidly over the western ranges. Hereford bulls are of immense value in grading up common herds because of the transmission of their fine beef qualities and ability to stand hard conditions. On account of hardiness and early maturity, Hereford steers stand in front rank as feeders.

Aberdeen-Angus. This breed of hornless cattle originated in and around the county of Aberdeen, in Scotland, taking its

name from the county and a near-by locality. While something had been done before, the real work of improving this breed began about 1815. Aberdeen-Angus cattle are not as large as Shorthorns and Herefords, but are more cylindrical

FIG. 183. Aberdeen-Angus bull.
Courtesy of R. F. Hildebrand.

and compact in shape and are remarkably heavy for their size. Bulls weigh two thousand to twenty-two hundred pounds, cows fourteen hundred to fifteen hundred pounds, both sexes frequently passing these marks. The breed is noted for its smoothness, high percentage of dressed beef, and the superior quality of the meat. The standard color is black, though occasionally solid reds appear. The *poll*, or top of the head, is a well-marked characteristic. It should be clearly defined and prominent, and there should

be no traces of *rudimentary* * (rṳ dĭ mĕn'tȧ rȳ) horns. The cows produce more milk than Herefords, but less than Shorthorns.

This breed was first brought to America in 1873, and has become quite widely spread and popular considering the short time it has been here. It has gained much favor in the upper Mississippi Valley and in the Western and Southwestern States. The bulls are excellent for grading up a herd, and the steers make excellent feeders. The absence of horns makes it possible to feed them in close quarters without danger of their injuring each other. While good on the range *the Aberdeen-Angus* is hardly the equal of the Hereford in this respect.

The Galloway originated also in Scotland, in the ancient province of that name. Little is known of its origin, but its improvement was begun early in the eighteenth century. On account of the cold, damp climate and the mountainous nature of the country the cattle were obliged to have very robust constitutions, which is a noted and important point in favor of the Galloway. It is the smallest of the principal beef breeds, usually very short of leg and long of body. The head is hornless, but, unlike the Aberdeen-Angus, the poll is rather flat. The hair, instead of being short and smooth as that of the Aberdeen-Angus, is long and shaggy. The breed is often called the "shaggy coat." The hides often bring high prices for use in making rugs, robes, and overcoats. The color is black, with reddish or brownish tint frequently occurring in the black. The breed is criticised for lack of spring and fulness of rib, thin covering of loin, and slow

* A rudimentary horn is one that makes a beginning but never develops.

response to generous feeding. On these points it is now being rapidly improved.

Galloways were introduced into the United States and Canada early in the nineteenth century, but have gained more favor in Canada than in the United States, where they are not

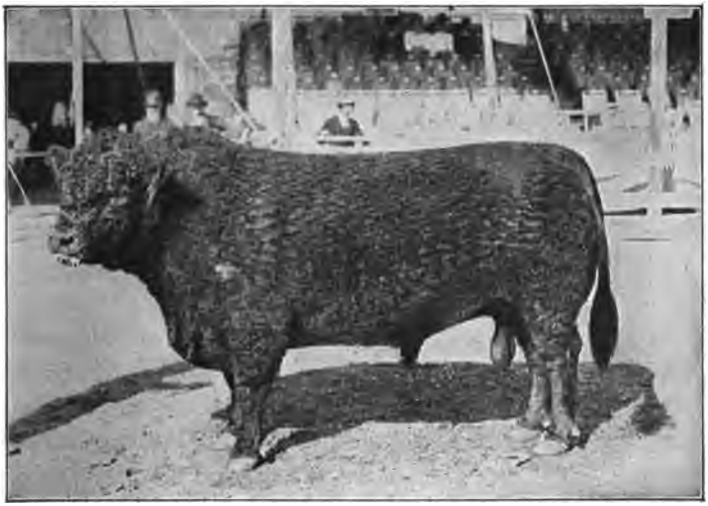

FIG. 184. Galloway bull.
Courtesy of R. F. Hildebrand.

nearly so popular as the three leading breeds. Its strong constitution, long, thick hair, and ability to find food make it well adapted to the cold Northwest and to the mountains. It is not well adapted to the warm South. There are a few Galloways in Texas, principally in the west, where Galloway bulls are used to some extent in grading up the herds.

Polled Durham cattle had their origin in the United States. About 1870 pure-bred Shorthorn bulls were bred to hornless

cows and the offspring that inherited the hornlessness of the mother but the other qualities of the Shorthorn were selected, and by continuous breeding and selection the polled breed of Shorthorns, called Polled Durham, was produced. Those bred in this way are called "single standard." Another breed of polled cattle was developed by selecting a few pure-bred Shorthorn bulls and cows that varied from the normal in having no horns. These were bred to each other and the polled feature fixed in the offspring. Polled Durhams that originated in this way are called "double standard."

A *Polled Hereford* breed of cattle has been developed recently also in the United States by breeding to each other Herefords that did not have horns.

The *Sussex* breed originated in England and the *West Highland* breed in the highlands of Scotland. The first is solid red and nearly as large as the Hereford, and is possibly related to this breed. The latter is a low-set, shaggy mountain type. Neither has any prominence in America.

262. **Dairy Cattle.**—A good dairy cow will return in milk and butter for a given amount of foodstuff a larger amount of human food than will the hog, sheep, chicken, or steer. This fact coupled with the ever-present demand for the products of the dairy make dairying, when properly conducted, a most profitable business. No kind of live-stock will as a rule yield a larger return from an acre of land than dairy cattle. In States that are thickly populated, and in which land is expensive, dairying is usually one of the chief occupations.

263. **Texas is Especially Suited to Dairying.**—In many of the more thickly populated sections of Texas dairying has made considerable advance in recent years, but the State is still wofully behind in this important field. As a rule farm-

ers keep a very poor grade of cows and do not handle the milk and butter in a scientific way. The result is that not half the butter is made that should be, and so large a part of that made is of such poor quality that when Wisconsin butter

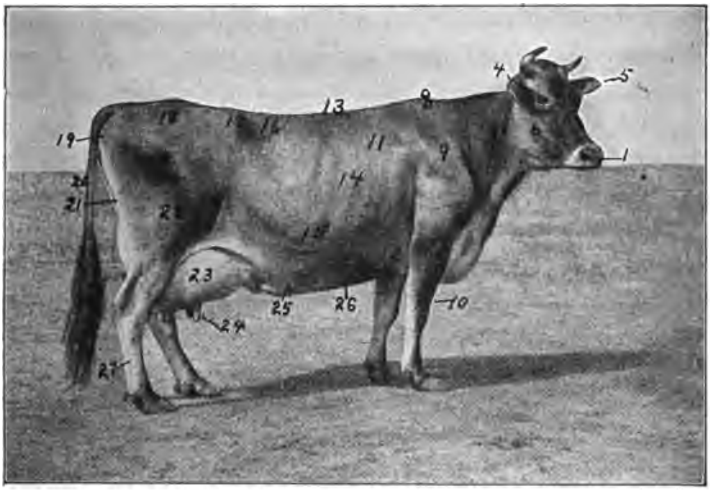

FIG. 185. Points of the dairy cow: 1, muzzle; 2, face; 3, forehead; 4, eye; 5, ear; 6, jaw; 7, neck; 8, withers; 9, shoulder; 10, fore leg; 11, crops; 12, chest; 13, back; 14, ribs; 15, barrel; 16, loin; 17, hips; 18, rump; 19, pin bones; 20, tail; 21, escutcheon; 22, thigh; 23, udder; 24, teats; 25, milk veins; 26, milk wells; 27, hind leg.

Courtesy of A. O. Auten.

is quoted in the market at thirty cents a pound, Texas country butter is quoted at fifteen cents. Here, where the cows can stay in the open all the year and can every day find fresh, green, succulent food, which is especially important for dairy cows, it is a discredit to our intelligence and industry to continue longer to buy our butter from States that have the ground covered with snow for three months of the year. We

cannot hope to compete with other States as long as we use cows that produce one hundred and fifty or two hundred pounds of butter a year, while they use cows that produce five hundred pounds, or even eleven hundred and twenty-six pounds, as the Jersey, Jacoba Irene, did, or twelve hundred and forty-seven pounds, as the Holstein, Colantha Fourth's Johanna, did. Our farmers and farmer boys and girls must learn about the judging, breeding, and feeding of dairy cattle, and about the production of milk and butter, before the State can take the high position in dairying that its natural advantages entitle it to hold. Let us begin the study now.

264. **Judging the Dairy Cow.**—A dairy cow may be looked upon as a factory which takes in raw material in the shape of food and makes it into milk and butter fat. If this were all that had to be considered, the best dairy cow would be the one that yielded the largest amount of milk and butter fat from the smallest amount of food. By measuring the food given and the milk produced and testing the per cent of fat with the Babcock test * each day, one could keep records that would make it possible to judge the quality of the cow accurately. But at times dairy cows must be judged when they are not giving milk, and when there are no records to go by. Furthermore, there are other qualities besides capacity for milk production that must be considered, such

* This is a test which was originated by Professor Babcock, of the University of Wisconsin, for finding out the percentage of butter fat in milk. A little sulphuric acid is added to a bottle of milk, which causes the fat to be separated from the rest of the milk. The bottle is then rotated rapidly in a machine in such manner as to bring the cream to the top of the bottle. A scale is marked along the top part of the bottle by which the per cent of cream present can be seen at once.

as capacity to produce regularly offspring that will inherit the fine qualities of the parent, and capacity to maintain vigor for a number of years. For these reasons it is necessary to learn to judge the qualities of a dairy cow by her physical make-up in a manner similar to that by which the qualities of beef cattle are judged.

265. **How Milk is Produced in the Cow.**—In the beef type of cow the food consumed is in part turned into flesh and stored within the animal's body, but in the dairy type the food is turned into milk which is constantly being taken away from the body. We should therefore expect the two types to be very different in appearance. But before we can know what the differences are and intelligently determine what is the best type for dairy purposes, we must know more about the means by which milk is produced in the cow. The parts most concerned in the production of milk are the digestive organs, the blood, the lungs, the heart, the udder, and the nervous system.

The digestive system must be strong enough to enable the cow to consume and digest a large quantity of food in order to produce a great quantity of milk. She should therefore show a large middle, or "barrel," as it is called.

The blood, lungs, and *heart.* After the food has been digested or changed into a condition to be utilized by the animal it passes through the walls of the intestines into the blood. The material from which milk is to be formed thus becomes a part of the blood, which now goes through a large vein to the right side of the heart. From here it goes to the lungs to be purified by the air that is breathed in. It then returns to the heart, this time to the left side, and from there is pumped through the arteries to the various portions

of the body. A part of it passes through a large artery under the backbone to the hind-quarters. Here this artery sends out a large branch, which in turn throws out several smaller branches that distribute the blood through all the regions

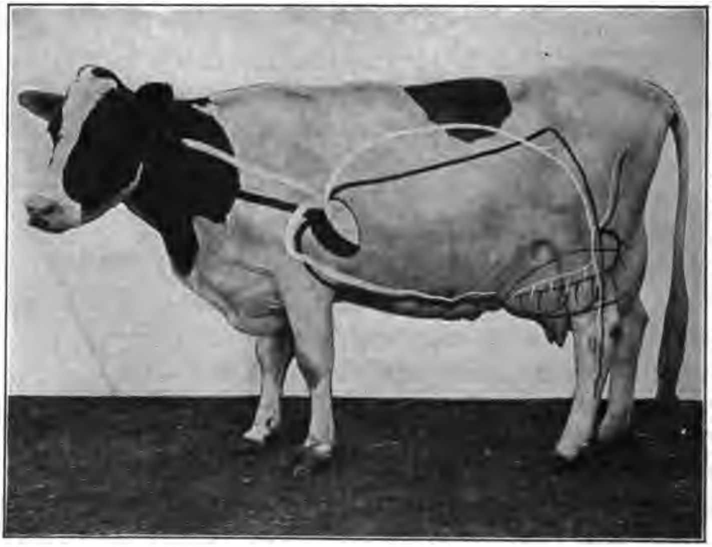

Fig. 186. The blood supply of the udder. Arteries (in white) lead from the heart to the udder, veins (in black) lead from the udder to the heart.
From Circular No. 29, Purdue University

of the *udder*. After the blood has passed through the udder it appears on the outside of it in what are called the *milk veins*. These pass along the belly for some distance in front of the udder, enter the body walls through *milk wells*, and carry the blood back to the heart.

It is thus seen that the heart, lungs, arteries, and veins are of great importance in the manufacture of milk. The part

played by the heart and lungs shows that it is very important for the cow to have a deep, wide, full chest, indicating that these organs are well developed and that she possesses a strong constitution. The size of the milk veins and milk wells is an indication of the amount of blood that passes through the udder to supply material for the manufacture of milk. On this account it is important that they be large.

The udder. It is in the udder that the process of making milk from the material supplied by the blood is carried on. The udder serves also as a reservoir for the milk after it has been made until withdrawn by the process of milking. It is especially important that the udder have a large capacity, and to this end it should be attached high behind and carried well forward. The quarters should be even and free from fleshiness. When empty it should appear to consist of folds of soft, pliable, elastic skin.

The nervous system, represented by the brain and the spinal cord with its branches, controls the action of the various organs of the body. In the dairy cow it is very important that the nervous system be strong and well developed in order that the organs concerned in the manufacture of milk may carry on their work most effectively. The cow with a nervous system of this kind is spoken of as having a nervous temperament. This does not mean that she is irritable and excitable, as the term often implies, but that she possesses a strong set of nerves that has the various organs of the body under good control. The nervous temperament in the dairy cow is indicated by a lean yet vigorous condition, showing that the feed she consumes is being used chiefly in the production of milk and not in the laying on of flesh. An animal of this temperament is active and wide awake. The tempera-

ment of the beef animal differs from that of the dairy animal, being what is called a *lymphatic* or lazy temperament, which is conducive to the laying on of flesh. Dairy cows that show

FIG. 187. Colantha Fourth's Johanna, the Holstein-Friesian cow that gave 27,432½ pounds of milk in one year. From this milk 1,247.8 pounds of butter were produced. Note the typical wedge (*B A C*) shape of the dairy cow.
Courtesy of the University of Wisconsin.

a beefy tendency are not utilizing their food for milk production as they should.

266. **The Dairy Type.**—Having learned the parts of the dairy cow that are chiefly involved in milk production, we are now in a position to understand the dairy type. We can see that the digestive organs and the udder, on account of the important work they perform, should be highly developed. We can see also that the dairy cow should be lean in condition. A lean head, a rather long, thin neck, lean, thin withers, thinly fleshed back, ribs, loin, and rump, and thin, long thighs characterize the nervous temperament. The

good dairy cow must also be wide of loin, hips, and rump. The high development of barrel and udder, the width of the loin, hips, and rump, together with the thin neck and lean condition throughout, give the dairy cow a wedge-shaped form. Three wedges may be seen, as indicated in Figures 187 and 188. This peculiar type which is so closely associated with high milk production has been intensified in each breed of dairy cattle by many years of careful breeding. The points in detail to be considered in judging dairy cows are given in the score-card on the next page.

FIG. 188. Note the wedges *B A C* and *D A E*, characteristic of the dairy type. *Courtesy of the Agricultural and Mechanical College of Texas.*

267. **Breed Type.**—In addition to judging the dairy cow by the points indicated on the score-card as a milk producer, she should be judged also as a breeder. The points to consider here are the same as those given for the breeder type when discussing beef cattle.

268. **The Dairy Bull.**—The dairy bull may be judged by the records of his daughters as milk producers, but this method can be applied only to old bulls. The more common method is to judge by his agreement with a certain type proved to be valuable, and by the records of his ancestors. A bull from good parents, grandparents, and great-grand-

SCORE-CARD

From "Judging Live Stock," by J. A. Craig

DAIRY CATTLE **COW**

SCALE OF POINTS	STANDARD	POINTS DEFICIENT	
		STUDENT'S SCORE	CORRECTED
GENERAL APPEARANCE			
FORM, inclined to be wedge-shaped	6	......	......
QUALITY, hair fine, soft; skin mellow, loose, medium thickness; secretion yellow; bone clean, fine	6	......	......
TEMPERAMENT, nervous, indicated by lean appearance when in milk	6	......	......
HEAD AND NECK			
MUZZLE, clean cut; mouth large; nostrils large	1	......	......
EYES, large, bright, full, mild	1	......	......
FACE, lean, long, quiet expression	1	......	......
FOREHEAD, broad	1	......	......
EARS, medium size, yellow inside, fine texture	1	......	......
HORNS, fine texture, waxy	1	......	......
NECK, fine, medium length, throat clean, light dewlap	1	......	......
FORE-QUARTERS			
WITHERS, lean, thin	1	......	......
SHOULDERS, light, oblique	2	......	......
LEGS, straight, short; shank fine	2	......	......
BODY			
CHEST, deep, low, girth large with full fore-flank	10	......	......
BARREL, ribs broad, long, wide apart; large stomach	10	......	......
BACK, lean, straight, open-jointed	2	......	......
LOIN, broad	2	......	......
NAVEL, large	2	......	......
HIND-QUARTERS			
HIPS, far apart, level	2	......	......
RUMP, long, wide	2	......	......
PIN BONES, or THURLS, high, wide apart	1	......	......
TAIL, long, slim; fine hair in switch	1	......	......
THIGHS, thin, long	4	......	......
ESCUTCHEON, spreading over thighs, extending high and wide; large thigh ovals	2	......	......
UDDER, long, attached high and full behind, extending far in front and full, flexible; quarters even and free from fleshiness	20	......	......
TEATS, large, evenly placed	5	......	......
MAMMARY VEINS, large, long, tortuous, branched with double extension; large and numerous milk wells	5	......	......
LEGS, straight; shank fine	2	......	......
Total	100	......	......

parents is more likely to be a good breeder than one the ancestors of which are not of such merit. In judging the dairy bull the following points are especially important:

1. He should be typical of the breed he represents.

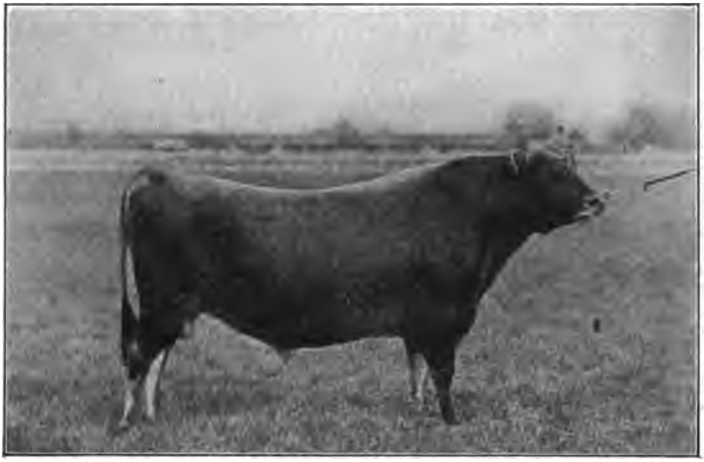

FIG. 189. **Fountaine's Chieftain, champion Jersey bull.**
Courtesy of R. F. Hildebrand.

2. He should show in general the spare, angular form characteristic of the dairy cow.

3. He should show distinctly the nervous temperament, as indicated by an active, wide-awake appearance and lean condition.

4. He should possess good quality, as indicated by dense, clean bone, soft hair, and loose, pliable skin of medium thickness.

5. He should show a strong masculine character, as indicated by bold expression of eyes, burly head, strong horns,

well-crested neck, and comparatively heavy though not coarse shoulders. The front of the dairy bull is necessarily much heavier than that of the dairy cow, but he should not show the same relative width of hips.

6. He should possess a strong constitution, as indicated by a deep, wide chest, large nostrils, bright, clear eyes, and a general appearance of health and vigor.

7. He should possess a large, capacious barrel, indicating plenty of room for food, for it is important that he be able to stamp this characteristic on his offspring.

8. He should possess a strong back, long, level rump and light, thin thighs, and should be cut up high in the twist. Thick, beefy thighs and deep, full twist are objectionable.

9. The rudimentary teats should be of good size and evenly placed, as they indicate to some extent the size and position of the teats in the female offspring.

269. **Breeds of Dairy Cattle.**—The breeds of dairy cattle mentioned in order of popularity in the United States are: the *Jersey,* the *Holstein-Friesian* (Hōl′stīn-Frē′zhăn), the *Guernsey* (Gûrn′zy̌), the *Ayrshire* (Âr′shẽr), the *Brown Swiss,* the *Dutch Belted,* the *French Canadian,* and the *Kerry.*

The Jersey came from a little island of that name in the English Channel, and is probably descended from two French types of cattle that had been taken to the island. As early as 1763 the interest in breeding a fine dairy type was strong enough to get a law passed forbidding the bringing to the island any cattle from France except for immediate slaughter. Soon similiar laws were made against cattle from other countries. Since 1833 the most rigorous selection has been carried on, with the result that the Jersey excels all other breeds in quality of milk and in beauty and refinement. In size

the Jersey ranks from medium to small. An average bull weighs about 1,300 pounds and an average cow about 850 pounds. There is, however, wide variation in weights of both bulls and cows. The color also varies considerably, a fawn-like color predominating. It may be a yellowish, red-

FIG. 190. Jersey cow.
Courtesy of A. O. Auten.

dish, grayish, brownish, or silvery fawn. Some are described as orange or lemon fawn, and others as squirrel gray or mulberry black. White markings often occur, but are not in favor. The Jersey is especially noted as a producer of rich milk, that is milk that contains a high percentage of butter fat. It is also noted for the comparatively large size of the fat globules in the milk, this being a great advantage on account of causing the cream to rise and separate easily.

The Jersey cow, Jacoba Irene, No. 146443, A. J. C. C., holds the record of her breed for butter production in an official test. She produced in one year 17,253 pounds of milk, from which was made 1,126 pounds 6 ounces of butter.

The importation of Jersey cattle to the United States began early in the nineteenth century, but importations did not become frequent until 1850. The Jersey is the most popular breed in the United States, and is now found in every State. Jersey cattle are numerous in Texas, where they have been in strong favor for many years, almost to the exclusion of other breeds. They are more widely distributed over the world than any other dairy breed.

Holstein-Friesian. The native home of this breed is Holland. Little is known about its origin, but it is claimed that cattle of the Holstein-Friesian type have been kept by the people of Holland for the production of milk, butter, and cheese for over a thousand years. The size of the breed is greater than that of any other dairy breed. The average weight of mature cows is from twelve hundred and fifty pounds to fourteen hundred, and of mature bulls from nineteen hundred to two thousand pounds. It is not uncommon for weights of both cows and bulls to exceed these figures. The color is black and white spotted, sometimes black predominating and sometimes the reverse. Black on the legs is considered objectionable. The Holstein-Friesian cow is famous for the large quantity of milk she produces. In this respect she is far ahead of all other breeds. The cow Colantha Fourth's Johanna, No. 48577, A. H. F. A., holds the world's record for quantity of milk in an official test. She produced in one year 27,432½ pounds of milk, from which were made 1,247.8 pounds of butter. The milk of the Holstein-

Friesian is not rich in butter fat, but a large quantity of butter is generally produced on account of the large yield of milk.

Holstein-Friesian cattle were probably first brought to the United States by the early Dutch settlers of New York.

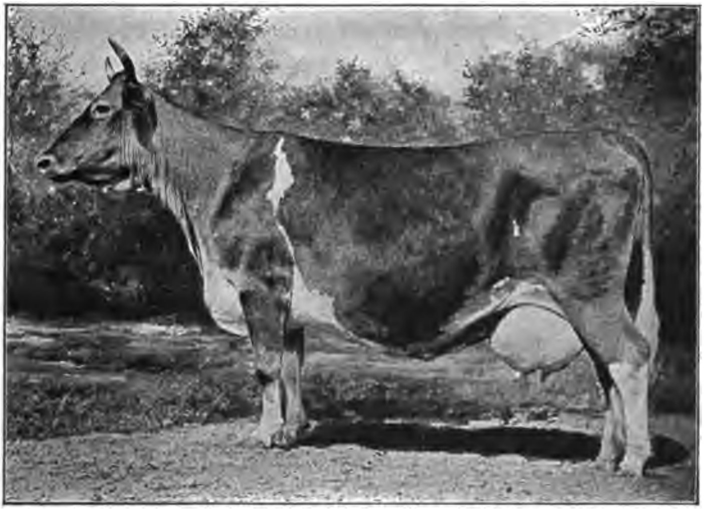

FIG. 191. Guernsey cow.
Courtesy of R. F. Hildebrand.

Since about the middle of the nineteenth century many importations have been made. The breed has become well distributed, though it has not gained the popularity of the Jersey. It would be well if a larger number of cattle of this breed were owned in Texas, for as yet the breed has not been given the attention in this State which its merit demands.

The Guernsey. This breed, the native home of which is the islands of Guernsey and Alderney, in the English Channel,

near the island of Jersey, has high merit. Several herds of Guernsey cattle are owned in the United States, chiefly in New England, New York, New Jersey, and Wisconsin. The breed, however, has not gained the prominence to which its merit entitles it. There are few Guernseys in Texas, though there is no reason why they should not do well here. The size of the Guernsey is generally larger than that of the Jersey, the average weight of mature cows being about a thousand and fifty pounds, and of mature bulls about fifteen hundred pounds. In color animals of this breed may be either yellowish, brownish, or reddish fawn, with white marking frequently occurring on body or legs.

The Ayrshire. The native home of this breed is in the county of Ayr, in southwestern Scotland. In size the breed ranks as medium, the average weight for mature cows and bulls being about the same as stated for the Guernsey breed. The color is white, with red or brown markings. The breed ranks high in yield of milk, which, however, is only fair in quality. Ayrshire cattle have been exported from Scotland to many different countries. In North America they are found chiefly in Quebec and Ontario, Canada, and in the New England and Eastern States of this country.

The Brown Swiss is a large rather beefy breed of dairy cattle whose native home is in Switzerland. On account of its beefy tendency it is classed by some as a dual-purpose animal.

The Dutch Belted breed had its origin in Holland, where it has been chiefly developed by the nobility of that country. The color is peculiar, being black, with a wide belt of white around the body between the shoulders and the hips. From the dairy stand-point the breed does not rank high.

The French Canadian breed of cattle originated in the province of Quebec, Canada. It is supposed that the foundation stock of the breed was imported from France by the early settlers before 1665. The breed has been kept pure

Fig. 192. Ayrshire cow.
Courtesy of R. F. Hildebrand.

for over a hundred years. It is noted for its vigorous, robust constitution. The color is generally black, though a brown brindle sometimes occurs. Though French Canadian cows rank well as milk producers, the breed is not distributed to any extent outside of Quebec.

The Kerry breed of cattle originated in western Ireland. It is a small breed, black in color and very hardy. The cows rank well as milk producers and the quality of the milk is

SCORE-CARD

From "Judging Live Stock," by J. A. Craig

RED POLLED CATTLE — COW

SCALE OF POINTS	STANDARD	POINTS DEFICIENT: STUDENT'S SCORE	POINTS DEFICIENT: CORRECTED
OBJECTIONS			
Scurs, or any evidence whatever of a horny growth on the head. Any white spots on body above lower line or brush of tail.			
COLOR—Any shade of red. The switch of tail and udder may be white, with some white running forward to the navel. Nose of a clear flesh color. Interior of ears should be of a yellowish, waxy color....................................	2	......	......
OBJECTIONS—An extreme dark or an extreme light red is not desirable. A cloudy nose or one with dark spots.			
HEAD—Of medium length, wide between the eyes, sloping gradually from above eyes to poll. The poll well defined and prominent, with a sharp dip behind it in centre of head. Ears of medium size and well carried. Eyes prominent; face well dished between the eyes. Muzzle wide, with large nostrils.........................	6	......	......
OBJECTIONS—A rounding or flat appearance of the poll. Head too long and narrow.			
NECK—Of medium length, clean cut, and straight from head to top of shoulder, with inclination to arch when fattened, and may show folds of loose skin underneath when in milking form....	3	......	......
SHOULDER—Of medium thickness and smoothly laid, coming up level with line of back..........	6	......	......
OBJECTIONS—Shoulder too prominent, giving the appearance of weakness in heart girth. Shoulder protruding above line of back.			
CHEST—Broad and deep, insuring constitution. Brisket prominent and coming well forward....	10	......	......
BACK AND RIBS—Back medium long, straight and level from withers to the setting on of tail; moderately wide, with spring of ribs starting from the backbone, giving a rounding appearance, with ribs flat and fairly wide apart.......	14	......	......
OBJECTIONS—Front ribs too straight, causing depression back of shoulders. Drop in back or loin below the top line.			

SCORE-CARD

(Continued)

RED POLLED CATTLE **COW**

SCALE OF POINTS	STANDARD	POINTS DEFICIENT	
		STUDENT'S SCORE	CORRECTED
HIPS—Wide, rounding over the hooks, and well covered	3	......	......
QUARTERS—Of good length, full, rounding, and level; thighs wide, roomy, and not too meaty...	6	......	......
OBJECTIONS—Prominent hooks, sunken quarters.			
TAIL—Tail head strong and setting well forward, long and tapering to a full switch	2	......	......
LEGS—Short, straight, squarely placed, medium bone	3	......	......
OBJECTIONS—Hocks crooked, legs placed too close together.			
FORE-UDDER—Full and flexible, reaching well forward, extending down level with hind-udder.	10	......	......
HIND-UDDER—Full and well up behind	10	......	......
TEATS—Well placed, wide apart, and of reasonably good size	4	......	......
OBJECTIONS—Lack of development, especially in forward udder. Udder too deep, "bottle-shaped," and teats too close together. Teats unevenly placed and either too large or too small.			
MILK VEINS—Of medium size, full, flexible, extending well forward, well retained within the body; milk wells of medium size	6	......	......
HIDE—Loose, mellow, flexible, inclined to thickness, with a good, full coat of soft hair	5	......	......
OBJECTIONS—Thin, papery skin or wiry hair.			
CONDITION—Healthy; moderate to liberal flesh evenly laid on; glossy coat; animal presented in good bloom	10	......	......
Total	100	......	......
GENERAL DESCRIPTION—Cow medium wedge form, low set, top and bottom lines straight except at flank, weight 1.300 lbs. to 1,500 lbs. when mature and finished.			

good. The breed is not generally found outside its native home.

270. **Dual-Purpose Cattle.**—Dual-purpose cattle have been bred for both beef and milk production. From what you have learned of the beef and dairy types it should be clear to you that both beef production and milk production cannot attain the highest degree of development in the same animal. We therefore find the dual-purpose type first class neither for beef nor for milk. Cattle of this type, however, meet the demand of many farmers for animals that will be superior to the dairy breeds for beef and superior to the beef breeds for milk. The two breeds of dual-purpose cattle of the most importance are the Red Polled and the Devon.

Red Polled. In the early part of the eighteenth century there existed a small, thin-fleshed, red-brindled, or dun-colored polled type of cattle in Suffolk, England, noted for its milk-producing qualities. About the same time in Norfolk there existed a type of cattle described as blood-red in color, with white or mottled face, having horns and possessing a strong tendency to fatten at an early age. These cattle were poor milkers, but of very good beef qualities. The red polled breed originated in a crossing of these two types. Careful selection was practised and the result was a polled dual-purpose breed, solid red in color. Mature males weigh from eighteen hundred to twenty-two hundred pounds and mature cows from eleven hundred to sixteen hundred pounds.

Red polled cattle were not imported into the United States to any extent until after 1873. They are now very well distributed throughout the Mississippi Valley States. They

seem well adapted to Texas conditions and several prominent herds are owned in this State.

Devon. The native home of this breed is in the counties of Devon and Somerset, England. The origin of the breed is obscure, but it is thought that it is directly descended from

FIG. 193. Red polled cow.
Courtesy of R. F. Hildebrand.

the native wild cattle of Great Britain and that it is one of the oldest of the British breeds. The size of the Devon is quite variable. As a milk producer the Devon holds only a medium rank. Animals of this breed were probably among the first pure-bred cattle to be imported to the United States. Though the breed is now fairly well scattered over the United States, it has never gained much popularity. Very few Devons are found in Texas.

The Cattle Tick

271. **Cause of Tick Fever.**—One of the most expensive diseases the South has ever known is the cattle "tick fever," as this disease is now called. For many years the losses through this fever from death, quarantine, and other effects have been estimated at over $40,000,000 a year. The scientists of our Agricultural and Mechanical College and of the United States Department of Agriculture have now discovered the cause of this fever and devised methods of completely eradicating it. The fever was found to be caused by parasites which are taken in by ticks when biting infected cows. The parasites are then carried to other animals that are afterward bitten by these ticks, and are even transmitted to the eggs of the tick, and in this way to the next generation.

272. **Valuable Results of the Discovery.**—When it was found that ticks caused the fever, and that they could be removed from cattle by oil and other dips, the rigid quarantine against Southern cattle was modified, and a considerable part of this expensive handicap was removed.

Perhaps the worst injury from the tick arose out of the fact that about four-fifths of the fine-blooded cattle imported into the Southwest to breed up our scrub herds were given the fever. As they were less resistant to the fever than the native cattle, most of them died. This prevented the rapid improvement of our stock. The scientists next discovered that by injecting some of the blood of a native cow directly into a well one, the healthy animal would be given the fever. The fever properly transmitted in this way is not especially dangerous, as is shown by the fact that only five per cent of the animals infected die, whereas eighty per cent

die from the fever caused directly by tick bite. The fever caused by direct inoculation, as this method is called, makes the animal immune to the disease thereafter in all forms. Now that this has been learned it is possible to import and

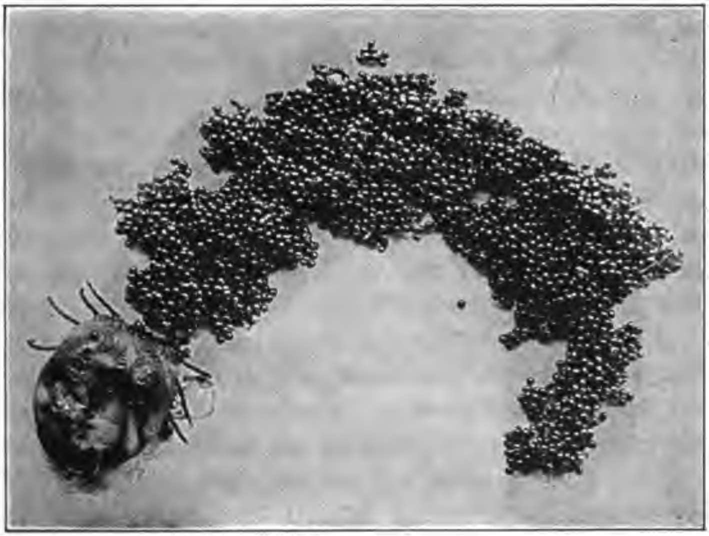

FIG. 194. Cattle tick depositing eggs.
Courtesy of the U. S. Department of Agriculture.

inoculate the finest young bulls and heifers and breed up our low-grade herds economically. This great handicap being removed, the South can now come rapidly to the front in the raising of fine-blooded cattle.

273. **Exterminating Ticks.**—By careful study of the habits and life cycle of the ticks, a method of entirely ridding the pastures of them has been devised, and the ticks have been cleared out of a large number of States and will soon be

wiped out of the United States. Investigators found that the grown female tick, when filled with blood, drops from the cow and lays about three thousand eggs. In warm weather tiny ticks soon hatch out and climb upon vegetation, where they are rubbed off by passing stock. As ticks can live only on blood, if no animal of the right kind is found, they finally starve to death. In summer they can live without food for about three months and in winter much longer.

The method of exterminating ticks is simple. The cattle are brought in from the pastures about once in two weeks and dipped in a solution that kills the ticks. In this way the only young ticks that can live to reproduce, namely, those upon the cattle, are killed before they have got their fill of blood and have dropped off and laid a new lot of eggs. This method does not necessarily kill all the ticks in a pasture, because there are other varieties of ticks that live on other animals. It does destroy the particular variety of tick that lives on cattle and transmits tick fever. In this way it clears the pasture of infected, fever-producing ticks.

QUESTIONS, PROBLEMS, AND EXERCISES

160. Make a list of all the reasons for and against raising stock on your farm.
161. How many beef cattle are on your farm? What is their value per head? How could their value be increased in a practical and economical manner?
162. How many dairy cattle are on your farm? How much milk and butter per year does each cow produce? How much more would these pay per year if each one produced one-half as much as the Jersey Irene?

163. Make what you consider a practical plan for live-stock raising on your farm. Discuss this with the teacher and then at home.
164. How many of each of the following could be raised on your farm without interfering with the crops now grown there: 1, cattle; 2, horses; 3, sheep or goats; 4, hogs; 5, chickens and other fowls?
165. How many breeds of cattle are there in your community and what are they?
166. Find what kinds of pure-bred cattle are in your neighborhood and, together with the teacher and remainder of the class, make a visit, inspect, and score each variety.
167. Find and score one good specimen of each of these types: good feeder, poor feeder, fat steer, good breeder, poor breeder.

If teacher and pupils can go together to a county or State fair and practise judging it will be very helpful.

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Farmers' Bulletins:

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No. 350. "The Dehorning of Cattle."
No. 380. "The Loco-Weed Disease."
No. 439. "Anthrax, with Special Reference to Its Suppression."
No. 569. "Texas or Tick Fever."
No. 612. "Breeds of Beef Cattle."
No. 614. "A Corn-Belt Farming System Which Saves Harvest Labor by Hogging Down Crops."
No. 666. "Foot and Mouth Disease."
No. 720. "Prevention of Losses by Stock from Poisonous Plants."
No. 790. "Contagious Abortion in Cattle."
No. 857. "Screwworms and Other Maggots Affecting Cattle."
No. 949. "Dehorning and Castration of Cattle."
No. 1008. "Saving Farm Labor by Harvesting with Live Stock."
No. 1057. "Cattle-fever Tick."

No. 1068. "Judging Beef Cattle."
No. 1069. "Tuberculosis in Live Stock."
No. 1073. "Growing Beef on the Farm."
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No. 68. "Diseases of the Stomach and Bowels of Cattle."
No. 89. "The Preparation of Emulsions of Crude Petroleum." (For cattle parasites.)
No. 97. "How to Get Rid of Cattle Ticks."
No. 98. "Some Unusual Host Relations of Texas-Fever Tick."
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No. 25. "The Ox Warble."
No. 456. "Cropping System for Stock Farm."

CHAPTER XIII

THE CARE OF MILK AND ITS PRODUCTS

274. **What is Necessary in Dairying.**—The first necessity in the economical production of milk, butter, and cheese is well-selected dairy cows. After securing cows of the right type one must then learn to handle the milk and butter properly and to feed economically before he can secure the largest return from his herd. Let us see what good milk and butter are and how they are produced. Later we shall study feeding.

275. **What Milk Is.**—We have seen that in the good dairy cow a large supply of blood is carried to the udder, where there are organs which can utilize the materials brought by the blood in manufacturing milk. As the milk is made from the materials in the blood, the quality of the milk depends to a certain extent upon what food materials are in the blood, as well as upon the kind of milk-secreting organs there are in the udder. This is why milk from cows that are being fed on clover and peas has a different flavor from that produced by cows that are fed on cotton-seed meal. When cows have been

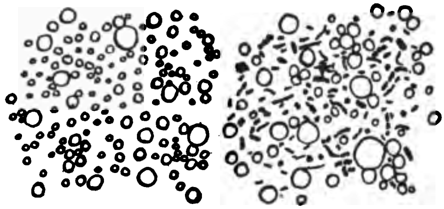

Fig. 196. On the left, pure freshly drawn milk as it looks under the microscope; on the right, impure milk.

eating onions, for example, the flavor of the milk is directly affected.

The composition of milk varies with different breeds, and even with different individuals of the same breed. As a rule Holstein milk, for example, has about three and five-tenths per cent fat, while Jersey milk has about five and four-tenths per cent, yet some Holstein cow may have a much higher percentage of fat than the average and some Jersey much lower than the average. The ingredients of milk are usually in about the following proportions:

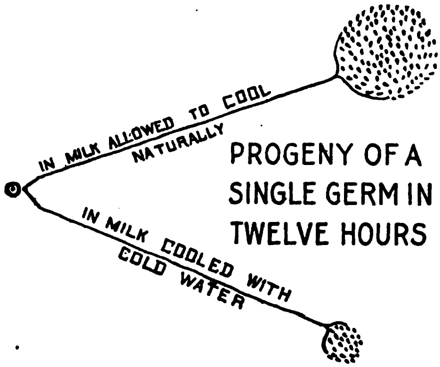

Fig. 197.

Water	87.0	per	cent
Fat	4.0	"	"
Protein	3.2	"	"
Sugar	5.1	"	"
Ash	.7	"	"

The sweet taste of fresh milk is due to the milk-sugar in it. Milk also contains bacteria which work on this sugar and produce an acid that gives the taste to sour milk.

276. **Why Milk Sours and How to Prevent It.**—When milk is kept at a temperatue of 75 to 100 degrees the bacteria in it multiply so rapidly that in ten to twelve hours the milk is sour. It is not practicable or desirable to keep these *lactic-acid* bacteria, as these are called, entirely out of milk, but if, as soon as it is drawn, the milk is cooled to a temperature

of about 40 degrees and is kept cool the bacteria multiply very slowly and the milk will remain sweet much longer. Even at a temperature of 55 or 60 degrees the bacteria multiply slowly. Milk should therefore always be cooled as soon as drawn. Furthermore, every precaution should be taken to prevent bacteria from getting into it. At milking-time the cows and stables must be clean and free from dust, and before milking the cows must be brushed off and the udders washed and wiped clean. The hands of the person milking should be carefully washed before he begins to milk, and whenever soiled afterward. The milk-pail should have a top that will admit a minimum of dust (see Figure 198). All milk vessels, no matter how well washed in warm or cold water, still have tiny particles of dried milk left in the cracks and angles. These tiny specks contain thousands of bacteria which will rapidly multiply in the next sweet milk that is put into the vessel and sour it. For this reason all milk vessels should be washed very carefully and sunned and should then be scalded before being used in order to kill all bacteria on them. If these precautions are taken, milk should keep sweet without ice for a day or two in even the hottest weather, provided it is cooled with spring or well water immediately after it is drawn and kept cool with running water or by the evaporation of water around it.

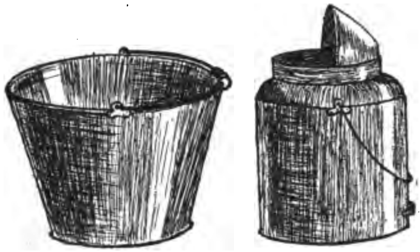

FIG. 198. Into which milk-pail will most dust and germs fall?

277. **Danger in Milk.**—There are not only lactic-acid bacteria in milk, but many other bacteria are liable to get into it from the air, the vessels, and the persons handling it. Once in the milk, these bacteria thrive and multiply with wonderful rapidity. Fortunately many of them are harmless, but

Fig. 199. A sanitary and conveniently arranged dairy barn. *Courtesy of "Farm and Ranch."*

others are very dangerous. Typhoid fever, scarlet fever, tuberculosis, and many other serious diseases may be carried in milk. For this reason no one with a germ disease should work around a dairy or handle milk. The vessels and milk should always be protected from dust and especially from flies. The vessels should be washed only in water that is known to be pure. Two hundred and thirty-six people were given typhoid fever by one dairy at which the milk-cans were washed in an infected stream. If milk is not kept

scrupulously clean it is very dangerous. If it is not kept cool the bacteria in it multiply so rapidly that it is soon unfit for use. When properly cared for it is one of the best and most wholesome of foods, except to an occasional person who cannot digest it well.

278. **Cream.**—The cream which rises to the top when milk stands for several hours is composed mainly of butter fat.

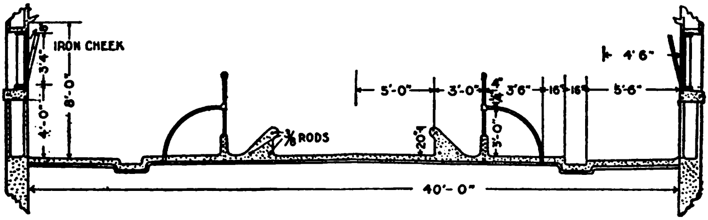

FIG. 200. Cross-section of a model barn, showing arrangement of stalls, feed-troughs, etc.

This fat, which is composed of round globules so small that it takes six thousand of them side by side to measure an inch, is lighter than the rest of the milk, and hence it rises to the top when milk is allowed to stand. Cream may be separated immediately from the milk by a mechanical *separator*, in which the vessel of milk is rotated six thousand or more revolutions per minute. This rapid revolution tends to throw the milk off from the centre of the vessel, as mud or water is thrown from a revolving wheel. The heavier part of the milk is thrown harder and hence is driven to the outer part of the vessel and the light cream is thus squeezed to the centre. The milk escapes through an opening at the outer edge of the vessel and the cream through one at the centre. In this way the immediate separation is brought about. Milk can be more perfectly separated in this way

than by allowing it to stand until the cream rises and then skimming.

279. **Butter.**—Butter is nearly pure fat, there being in ordinary butter about eighty-two per cent fat, fourteen per

Fig. 201. Famous model dairy barn, Wisconsin State fair grounds.
Courtesy of " Farm and Ranch."

cent water, two and five-tenths per cent salt, and one and five-tenths per cent casein (kā′sĕ ĭn) and milk-sugar. It is produced by stirring or agitating the cream until the tiny globules of butter fat gather into granules, or small lumps. The cream may be agitated while still sweet, or may be first ripened or soured. The product of the first is called sweet-cream butter, the latter produces the ordinary or sour-cream butter. The peculiar flavor of butter which is so highly

prized is given to it by the lactic-acid bacteria. If the milk is kept too cold, these will not develop rapidly and the milk will sour so slowly that in the mean time other bacteria in the milk which stand cold better will develop sufficiently to give an unpleasant flavor to the butter and buttermilk. On the other hand, if the milk is kept too warm the lactic-acid bacteria will develop too rapidly, the butter will be soft and of poor quality and the buttermilk too sour. Sixty to seventy degrees is a good temperature at which to ripen cream. Fifty degrees is the temperature used in some dairies.

A good temperature for churning is sixty degrees. When cotton-seed meal is being fed to the cows, about five degrees higher is better. It is a waste of time to churn cream that is at too low a temperature. If the temperature is too high the butter will be soft and mixed with the curds of the milk. A dairy thermometer costs very little and should always be used. The best churns are those that revolve. They should not be filled more than one-third to one-half full when churning. As soon as the grains of butter become as large as grains of wheat, draw off the buttermilk and add cold water to harden the butter. Then take the butter up, wash thoroughly, work it, and add fine dairy salt. Usually butter is worked twice, but care must be used, as too much working spoils the grain of the butter. When butter comes slowly it may be because the cream is not sour enough, not warm enough, or the churn is too full. The remedies for the last two are plain. For the first a small amount of buttermilk may be added to the cream to hasten souring. In cold weather it is often desirable to add a little buttermilk to cream to hasten souring. Butter, like milk, must be handled

with the greatest cleanliness, and should not be placed near anything having a strong odor, as it absorbs odors easily.

280. **Cheese.**—Cheese is also made from milk. It consists principally of the protein part of the milk called casein, together with varying amounts of fat and water. In order to make the American cheese, such as is usually sold in the grocery stores, the casein is first precipitated by rennet, which is put into the milk for that purpose. When the casein and fat are precipitated the whey is drawn off and the fat and casein heated, drained, salted, compressed, and cured or ripened. The ripening requires from several weeks to several months, and usually demands cold storage and expert handling. Bacteria also play an important part in the making of cheese and giving its flavor, but this must be left for later study, as must the making of all the other kinds of cheese except cottage-cheese.

Cottage-Cheese, or cream cheese, is very easy to make, and may be prepared in any home. The milk is allowed to clabber, then heated slightly to hasten the separation of the curd and whey. It is then hung in a cheese-cloth bag or put into metal moulds which are made for the purpose and left till the whey is all drained out and the curd firm. It may be pressed into moulds and kept for several days if kept at a low temperature. When eaten it may be flavored with salt or served with sweet cream and sugar.

281. **Sterilizing and Pasteurizing Milk.**—When milk is heated to the boiling point, 212 degrees, and boiled for a few minutes the germs in it are killed, so that it will keep sweet for a long time if protected from fresh infection. Such milk is said to be *sterilized* (stĕr′ĭl īzd). Unfortunately, milk when boiled loses some of its food value. For that and other

reasons milk is often heated to 140 degrees only and kept at this temperature for twenty minutes. This is called pasteurizing (păs′tŭr īz ĭng). If cooled promptly and kept cool, pasteurized milk will keep sweet for several days and will not have the cooked taste and other undesirable qualities of boiled milk. Pasteurizing kills bacteria, but does not kill spores, hence the milk is not sterile, and if it is allowed to get warm again the spores will develop. If milk must be used about the cleanliness of which there is any doubt, it should be pasteurized. Pasteurization does not take the place of cleanliness at all, but where it is impossible to keep milk cool, pasteurization will help to delay the souring.

FIG. 202. A small, inexpensive Babcock milk-tester.

QUESTIONS, PROBLEMS, AND EXERCISES

168. Study a dairy cow on your farm, locating all the points given in the text and figures.
169. Milk one quart of milk, using every precaution mentioned in the text, both in the milking and in the cleaning of the vessels. Place this beside a quart milked in the ordinary way and placed in vessels cleaned in the ordinary manner. Test both after ten, twelve, fifteen, eighteen, twenty-four hours to see which keeps best and has the best flavor.
170. Take three quarts of freshly drawn milk. Cool one at once to the temperature of spring or well water and keep it at that temperature. Wait an hour and then treat the second quart in the same way. Leave the third quart exposed to the summer heat all the time. Test these after six, ten, fifteen, and twenty-four hours and note the acidity and flavor of each.

171. Allow several gallons of fresh milk to clabber, churn one-third as soon as it is clabber, churn another third twelve hours later, and the other third twenty-four hours later. Note the effect in each case on the butter and on the buttermilk.
172. Take several gallons of sour milk, churn one-third of it at a temperature of fifty degrees, one-third at sixty, and one-third at seventy-five degrees. Note the effect of the different temperatures on the butter and buttermilk.
173. Take three quarts of fresh milk. Sterilize one, pasteurize another, do nothing to the third. Then place all three under the same conditions and taste each after twelve, eighteen, twenty-four, and forty-eight hours.
174. If your school has a Babcock tester, bring samples of milk from each cow and test for per cent of fat. Make test of milk drawn at the beginning of the milking and of that drawn when the udder is nearly empty.

REFERENCES FOR FURTHER READING

"Productive Dairying," R. M. Washburn.
"Manual of Milk Products," Stocking.
"The Story of Milk," J. D. Frederikson.
"Milk and Its Products," H. H. Wing.
"Modern Methods of Testing Milk and Milk Products," Van Slyke.

Farmers' Bulletins:

No. 206. "Milk Fever and Its Treatment."
No. 602. "Clean Milk: Production and Handling."
No. 742. "The Feeding of Dairy Cows."
No. 748. "A Simple Steam Sterilizer for Farm Dairy Utensils."
No. 850. "How to Make Cottage Cheese on the Farm."
No. 876. "Making Butter on the Farm."
No. 893. "Breeds of Dairy Cattle."
No. 930. "Marketing Butter and Cheese by Parcels-Post."
No. 960. "Neufchatel and Cream-Cheese Manufacturing and Use."
No. 976. "Cooling Milk and Cream on the Farm."

No. 1019. "Straining Milk."
No. 1207. "Milk and Its Uses in the Home."
No. 1214. "Farm Dairy Houses."

Texas Experiment Station:
Circular No. 15. "A Milk House for Texas."

The A. and M. College of Texas Extension Service Bulletins:
No. C-7. "Feeding the Dairy Cow."
No. 59. "Dairy Barn Plans."

CHAPTER XIV

HORSES

282. **The Modern Horse Not a Native of America.**—The horse has probably been associated with man longer than any other domestic animal. A prehistoric horse evidently existed in North America at one time, but the modern horse had its beginning here with the early settlement of the country by Europeans.

283. **Importance of Horse-Raising in Texas.**—Practically the whole State of Texas is well adapted to successful horse-raising, the western portion being especially so on account of its limestone soil and dry atmosphere. The former is excellent for the growth of bone and feet of good texture and the latter for the development of strong lungs, which are essential to stamina and endurance. The number of horses in Texas in January, 1910, was given as 1,369,000, and the average price per head as $73. The number of horses in Illinois at the same time was 1,655,000, with an average price of $124. Illinois ranks first in the Union in point of numbers, but in average value per head, New Jersey ranks first, with $134. Texas ranks third in point of numbers, but in average value per head this State ranks very low. This is because not enough attention has been given to the improvement of horses through careful selection and breeding. Every farmer who raises horses should strive to produce animals of a definite recognized market type. He should decide on the type

he wishes to produce and then work constantly toward that end. Only sound, pure-bred stallions should be used. It is just as cheap to raise a good horse that will fill a definite market class as an inferior one.

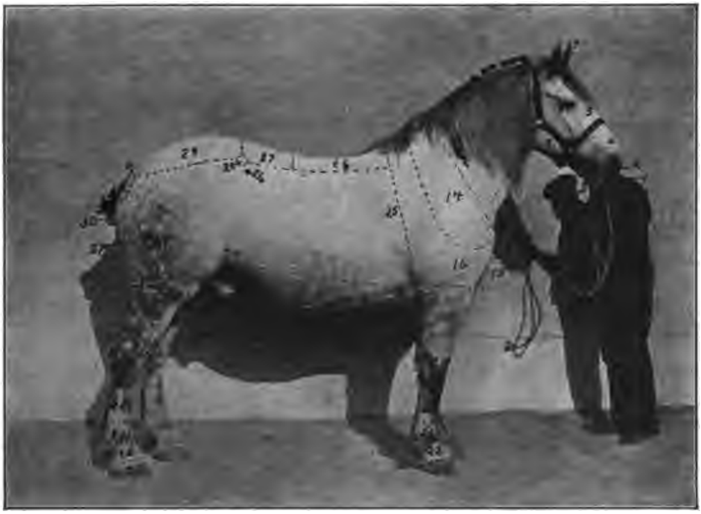

FIG. 203. Points of the horse: 1, mouth; 2, nostril; 3, chin; 4, nose; 5, face; 6, forehead; 7, ear; 8, eye ; 9, lower jaw; 10, throatlatch; 11, windpipe; 12, crest; 13, withers; 14, shoulders; 15, breast; 16, arm; 17, elbow; 18, forearm; 19, knee; 20, cannon; 21, fetlock-joint; 22, pastern; 23, foot; 24, foreflank; 25, heart girth; 26, back; 27, loin; 28, hip; 29, croup; 30, tail; 31, buttocks; 32, coupling; 33, belly; 34, rear-flank; 35, thigh; 36, stifle; 37, quarters; 38, gaskins, or lower thigh; 39, hock.

Courtesy of R. F. Hildebrand.

284. **Judging Horses.**—In judging horses it is usual to consider them in two general classes, namely, *heavy* or *draft horses* and *light horses*. Light horses are of three types: road, or light-harness horses; coach, or heavy-harness horses; saddle-horses.

Road-Horses. Horses of this class are used to draw light vehicles at a good rate of speed, which they must be able to maintain for a considerable distance without undue fatigue. Their chief characteristics are speed and stamina. The form is rather angular, the chest is very deep, and the loin and hind-quarters, where the propelling power and chief strength of the horse reside, are very muscular. Long muscles because of their elasticity, and long bones because they afford good leverage, are most favorable to speed. Good quality is indicated by clean bone, soft, pliable skin, silky hair. Clean-cut features throughout are characteristic of the good roadster and are of great importance from the fact that they are closely associated with both endurance and durability. In action the feet should be moved in a straight line and carried well forward rather than very high. The stride should be long, quick, and regular. Intelligence and courage are very important in the roadster and are generally possessed in a high degree in horses of this class.

Coach-Horses. Horses of this class are used chiefly for drawing heavy vehicles, such as carriages and coaches, at a moderate rate of speed and in good style. Symmetry of form and high, stylish action are their most marked qualities. Coach-horses range in weight from eleven hundred to fourteen hundred pounds, and in height from fifteen hands to sixteen hands one inch. The form of the coach-horse is more compact and more smoothly turned than that of the roadster. It is characterized by fulness and symmetry throughout, owing to the plumpness of the muscle over all parts. A rather small, clean-cut head neatly attached to a well-arched neck is characteristic of the best type of coach-horse and contributes much toward style. Such

horses also possess quality in a high degree. This is very important, not only on account of its association with durability, but because it adds greatly to the appearance of the animals. The coach-horse in action is a "high stepper."

Fig. 204. American trotting stallion.
Courtesy of "The Horse Review."

The action should be high, snappy, smooth, and graceful, the length of stride found in the roadster being sacrificed for high carriage of knees and hocks.

Saddle-Horses. The name of this class indicates the purpose for which horses belonging to it are used. Their weight ranges from nine hundred to twelve hundred pounds, and their height from fourteen hands three inches to sixteen hands. The typical saddle-horse with its smoothness and symmetry of form resembles somewhat the coach type, but

SCORE-CARD

From "Judging Live Stock," by J. A. Craig

LIGHT HORSES — MARKET

SCALE OF POINTS	STANDARD	POINTS DEFICIENT: STUDENT'S SCORE	POINTS DEFICIENT: CORRECTED
GENERAL APPEARANCE			
FORM, symmetrical, smooth, stylish	4	......	......
QUALITY, bone clean, firm, and indicating sufficient substance; tendons defined; hair and skin fine	4	......	......
TEMPERAMENT, active, kind disposition	4	......	......
HEAD AND NECK			
HEAD, lean, straight	1	......	......
MUZZLE, fine, nostrils large; lips thin, even; teeth sound	1	......	......
EYES, full, bright, clear, large	1	......	......
FOREHEAD, broad, full	1	......	......
EARS, medium size, pointed; well carried and not far apart	1	......	......
NECK, muscled; crest high; throatlatch fine; windpipe large	1	......	......
FORE-QUARTERS			
SHOULDERS, long, smooth, with muscle, oblique, extending into back	2	......	......
ARMS, short, thrown forward	1	......	......
FOREARMS, muscled, long, wide	2	......	......
KNEES, clean, wide, straight, deep, strongly supported	2	......	......
CANNONS, short, wide; sinews large, set back	2	......	......
FETLOCKS, wide, straight	1	......	......
PASTERNS, strong, angle with ground 45 degrees	3	......	......
FEET, medium, even size; straight; horn dense; frog large, elastic; bars strong; sole concave; heel wide	6	......	......
LEGS, viewed in front, a perpendicular line from the point of the shoulder should fall upon the centre of the knee, cannon, pastern, and foot. From the side a perpendicular line dropping from the centre of the elbow-joint should fall upon the centre of the knee and pastern joints and back of hoof	4	......	......

SCORE-CARD

(Continued)

LIGHT HORSES **MARKET**

SCALE OF POINTS	STANDARD	POINTS DEFICIENT: STUDENT'S SCORE	POINTS DEFICIENT: CORRECTED
BODY			
WITHERS, muscled and well finished at top	1	......	......
CHEST, deep, low, large girth	2	......	......
RIBS, long, sprung, close	2	......	......
BACK, straight, short, broad, muscled	2	......	......
LOIN, wide, short, thick	2	......	......
UNDERLINE, long; flank let down	1	......	......
HIND-QUARTERS			
HIPS, smooth, wide, level	2	......	......
CROUP, long, wide, muscular	2	......	......
TAIL, attached high, well carried	1	......	......
THIGHS, long, muscular, spread, open-angled	2	......	......
QUARTERS, heavily muscled, deep	2	......	......
GASKIN, or LOWER THIGHS, long, wide, muscular	2	......	......
HOCKS, clearly defined, wide, straight	5	......	......
CANNONS, short, wide; sinews large, set back	2	......	......
FETLOCKS, wide, straight	1	......	......
PASTERNS, strong, sloping	2	......	......
FEET, medium, even size; straight; horn dense, frog large, elastic; bars strong; sole concave; heel wide, high	4	......	......
LEGS, viewed from behind, a perpendicular line from the point of the buttock should fall upon the centre of the hock, cannon, pastern, and foot. From the side, a perpendicular line from the hip-joint should fall upon the centre of the foot and divide the gaskin in the middle; and a perpendicular line from the point of the buttock should run parallel with the line of the cannon	4	......	......
ACTION			
WALK, elastic, quick, balanced	5	......	......
TROT, rapid, straight, regular, high	15	......	......
Total	100	......	......

shows better quality or finish and better manners than any other class of horses. In beauty of form, style, and graceful carriage the best saddle-horses are unsurpassed. The action of the saddle-horse is very important. Besides being able to move in a straight, true manner, horses of this class should have the following gaits: (1) walk, (2) trot, (3) single foot, or rack, (4) canter, (5) slow pace, running walk, or fox trot. The market, however, recognizes a class of three-gaited saddle-horses, the gaits required being the walk, trot, and canter.

In judging all classes great emphasis should be placed on sound, properly constructed feet and legs and strength of constitution. The score-card on pages 350 and 351 presents the points in detail to be considered in judging light horses from the market stand-point.

Draft-Horses. Draft-horses range in weight from sixteen hundred pounds for the lighter sorts to twenty-two hundred pounds or even more for the heavier kinds. In height they range from fifteen hands three inches to seventeen hands. Weight, made up of heavy bone and muscle, is absolutely essential to the drafter in order that great power may be exerted in the collar. Whereas long, slender bones and muscles are conducive to quick action, comparatively short, heavy bones and thick muscles are conducive to power. The form of the typical draft-horse is therefore deep, wide, massive, and low set. Smoothness and symmetry, as in other classes of horses, are also highly desirable. The points indicating good quality and strong constitution must be present here as in all other types of stock. The expression "no foot no horse" is very often heard, but certainly is not applicable to any class of horses more than to draft-

ers. Their heavy bodies and the heavy work they have to do make large, sound, well-shaped feet and sound, properly constructed limbs of the utmost importance. The action of draft-horses should be especially good at the walk, this being the gait at which they are generally required to per-

FIG. 205. Draft type, Percheron gelding.
Courtesy of R. F. Hildebrand.

form their work. However, good action at the trot is also highly valued. The walk should be straight, smooth, quick, and well balanced, with good length of stride. The trot should be free, straight, and regular. The points in detail to be considered in judging draft-horses from the market stand-point are given in the card on pages 354 and 355.

285. **Judging for Breeding Purposes.**—In judging horses for breeding purposes the market demands must be kept in

SCORE-CARD

From Circular No. 29, Purdue University

DRAFT-HORSES **MARKET**

SCALE OF POINTS	STANDARD	POINTS DEFICIENT	
		STUDENT'S SCORE	CORRECTED
GENERAL APPEARANCE—19 PER CENT			
1. Height, estimated.... hands; actual.... hands			
2. Weight, over 1,600 lbs., estimated........lbs., actual......lbs., according to age..........	6	......	......
3. Form, broad, massive, well proportioned, blocky, symmetrical......................	4	......	......
4. Quality, refined; bone clean, hard, large, strong; tendons clean, defined; skin and hair fine; feather, if present, silky..............	6	......	......
5. Temperament, energetic; disposition good....	3	......	......
HEAD AND NECK—9 PER CENT			
6. Head, lean, proportionate size; profile straight.	1	......	......
7. Ears, medium size, well carried, alert.........	1	......	......
8. Forehead, broad, full......................	1	......	......
9. Eyes, full, bright, clear, same color...........	2	......	......
10. Lower jaw, angles wide, clean..............	1	......	......
11. Muzzle, neat; nostrils large, open, free from discharge; lips thin, even, firm..............	1	......	......
12. Neck, well muscled, arched; throatlatch clean; windpipe large..........................	2	......	......
FORE-QUARTERS—24 PER CENT			
13. Shoulders, moderately sloping, smooth, snug, extending into back......................	3	......	......
14. Arm, short, strongly muscled, thrown back, well set................................	1	......	......
15. Forearm, strongly muscled, wide, clean.......	2	......	......
16. Knees, deep, straight, wide, strongly supported	2	......	......
17. Cannons, short, wide, clean; tendons defined, set back................................	2	......	......
18. Fetlocks, wide, straight, strong, clean.......	1	......	......
19. Pasterns, moderate length, sloping, strong, clean	2	......	......
20. Feet, large, even size, sound; horn dense, waxy; sole concave; bars strong; frog large, elastic; heel wide and one-fourth to one-half the lineal length of toe............................	8	......	......
21. Legs, viewed in front, a perpendicular line from the point of the shoulder should fall upon the centre of the knee, cannon, pastern, and			

SCORE-CARD
(Continued)

DRAFT-HORSES **MARKET**

SCALE OF POINTS	STANDARD	POINTS DEFICIENT: STUDENT'S SCORE	POINTS DEFICIENT: CORRECTED
foot. From the side a perpendicular line dropping from the centre of the elbow-joint should fall upon the centre of the knee and pastern joints and back of the hoof..........	3	......	......
BODY—9 PER CENT			
22. CHEST, deep, wide, large girth...............	2	......	......
23. RIBS, long, well sprung, close; coupling strong..	2	......	......
24. BACK, straight, broad, strongly muscled.......	2	......	......
25. LOINS, wide, short, thickly muscled...........	2	......	......
26. UNDERLINE, low; flanks full..................	1	......	......
HIND-QUARTERS—30 PER CENT			
27. HIPS, broad, smooth, level, well muscled......	2	......	......
28. CROUP, not markedly drooping, wide, heavily muscled..............................	2	......	......
29. TAIL, stylishly set and carried...............	1	......	......
30. QUARTERS, deep, broad, heavily muscled, thighs strong..............................	3	......	......
31. GASKINS, long, wide, heavily muscled.........	2	......	......
32. HOCKS, large, clean, strong, wide, well set.....	6	......	......
33. CANNONS, short, wide, clean; tendons defined..	2	......	......
34. FETLOCKS, wide, straight, strong, clean.......	1	......	......
35. PASTERNS, moderately sloping, strong, clean...	2	......	......
36. FEET, large, even size, sound; horn dense, waxy; sole concave; bars strong; frog large, elastic; heel wide and one-fourth to one-half the lineal length of the toe	6	......	......
37. LEGS, viewed from behind, a perpendicular line from the point of the buttock should fall upon the centre of the hock, cannon, pastern, and foot. From side, a perpendicular line from the hip-joint should fall upon the centre of the foot and divide the gaskin in the middle, and a perpendicular line from the point of the buttock should run parallel with the line of the cannon..............................	3	......	......
ACTION—9 PER CENT			
38. WALK, fast, elastic, regular, straight..........	6	......	......
39. TROT, free, springy, balanced, straight........	3	......	......
Total.............................	100	......	......

mind, and in addition certain special breeding requirements. These are similar to those given under judging cattle for breeding purposes. The animal must always be pure bred, should be representative of its class and breed, should have

FIG. 206. Draft type, Clydesdale stallion.
Courtesy of R. F. Hildebrand.

a strong constitution and all the other marks of prepotency. The male should be distinctly masculine in his characteristics and the female distinctly femimine.

286. **Breeds of Light Horses.**—The principal breeds of light horses are as follows:

ROADSTER, OR LIGHT-HARNESS TYPE

American trotter and pacer.
Orloff trotter.

COACH, OR HEAVY-HARNESS TYPE

Hackney.
French coach.
German coach.
Cleveland bay.

SADDLE TYPE

American saddle-horse.

Other breeds of light horses are the Arab and thoroughbred.

The *Arab* breed is native to Arabia, where its development began several hundred years before the Christian era. It is therefore the oldest of our present-day breeds. It has been noted for its beauty of form, its style, quality, endurance, and intelligence. The size is not as great as that of the average roadster, the height being from fourteen to fourteen and one-half hands. The color may be white, gray, bay, chestnut, or black. The breed holds a place of great importance on account of the influence its blood has had in the development of many other breeds of light horses.

The *Thoroughbred* horse had its origin in England toward the end of the seventeenth century. During this period several strains of Oriental horses, among which was the Arab, were crossed on the lighter English horses, thus producing the thoroughbred type. The breed is noted for its running speed, endurance, and quality, and for the influence it has had in the development of other breeds, notably the American trotter and American saddle-horse. The height ranges from fourteen and one-half to sixteen and one-half hands, though from fifteen to fifteen and one-half hands is the most desirable height. The weight ranges from nine hundred to

ten hundred and fifty pounds. The color varies considerably, browns, bays, and chestnuts being most common. This breed has been used chiefly for racing, both here and in England.

American Trotter and Pacer. The trotter and the pacer

FIG. 207. Five-gaited saddle-horse.
Courtesy of R. F. Hildebrand.

are of the same breed, about the only difference being in the gaits. As the name indicates, this breed has been developed in the United States. It owes its origin chiefly to the thoroughbred. The work of development began in the early part of the nineteenth century. The chief characteristics of the breed have already been set forth in the description of the roadster. The type varies considerably, however, and in addition to roadsters the breed furnishes many horses that

are suited for carriage purposes. Practically all colors peculiar to horses are found among trotters and pacers, but brown and bay are the most common ones. The trotting mare Lou Dillon holds the world's trotting record for one mile, the time being one minute fifty-eight and one-half

Fig. 208. French coach stallion.
Courtesy of R. F. Hildebrand.

seconds. The pacing stallion Dan Patch holds the world's pacing record, the time being one minute fifty-five and one-half seconds.

Hackney. The native home of the hackney is England. The development of the breed began in the eighteenth century, Arabian, Barb, Turkish, and thoroughbred stallions being crossed with the native mares of Norfolk and careful selection practised. The result is a breed of much uni-

formity of type, presenting the best traits of the coach-horse. There is considerable variation in height, but fifteen and one-half to fifteen and three-quarters hands is the height desired by most breeders. The color varies a

Fig. 209. Hackney stallion.
Courtesy of R. F. Hildebrand.

great deal, chestnut, bay, and brown being common. A great many animals have white markings on legs, feet, and face.

The French Coach and German Coach are similar to the hackney, except that the German coach is a little larger and has not quite as good action.

American Saddle-Horse. Kentucky, Virginia, and Missouri have had most to do with the development of the American saddle-horse, often called the Kentucky saddle-

horse. The breed had its beginning during the early days of Kentucky, when there were no railroads and horseback travel was common, a condition that caused a demand for easy-gaited saddle-horses. The foundation of the breed was

FIG. 210. Belgian stallion.
Courtesy of R. F. Hildebrand.

laid in crossing thoroughbred stallions of easy saddle gait on light types of mares possessing the same characteristic. This was followed by careful selection and resulted in a type of much uniformity. The chief characteristics of the breed were given under the description of market classes of horses. The color varies, but blacks and bays are most common.

287. **Breeds of Draft-Horses.**—The principal breeds of draft-horses are the Percheron, the Clydesdale, the Shire, the Belgian, and the Suffolk.

The Percheron. The native home of the Percheron breed is France, chiefly in the district of La Perche. The best Percherons of to-day embody all the desirable features that were described in the discussion of the draft-horse. The color is generally gray or black. Mature stallions usually

FIG. 211. **Shire stallion.**
Courtesy of R. F. Hildebrand.

weigh from seventeen hundred to twenty-one hundred pounds and mature females from fifteen hundred to nineteen hundred pounds. The breed is now widely distributed in this country and is easily the leader of the draft breeds in popularity. A number of Percherons are owned in Texas and do well there.

The Clydesdale. Scotland is the native home of this breed, where its development began in the early part of the eigh-

teenth century. It is noted for its good feet, sloping pasterns, quality of bone, and good action. A thick fringe of hair occurs on the back of the legs along the cannons, which is termed "feather." The color is generally bay or brown, with white in the face and on some part or all of the legs below the knees and hocks. Though Clydesdales have been owned in the United States for many years, they have never gained the popularity here that they have in Canada. Clean-limbed horses are preferred by farmers here.

Fig. 212. A good team of mules.
Courtesy of A. and M. College of Texas.

The Shire. This breed of horses, which was developed in England, resembles somewhat the Clydesdale. The Shire is the largest of the draft breeds with the possible exception of the Belgian. Horses of this breed have been owned in the United States for many years, but the breed has never become popular.

The Belgian. The native home of this breed is Belgium, where it is bred under government supervision. Belgians are very compact and heavily built. Chestnut is the usual color, but roan, bay, and brown are common.

The Suffolk. This breed is native to Suffolk County, England. The color of the breed is always chestnut, varying from a light to a dark shade. The type is quite uniform. The weight is not generally as great as that of other draft-horses. Suffolks have been imported into the United States to a limited extent. A few Suffolks are owned in Texas and seem well adapted to this State.

288. **Mules.**—The mule is a hybrid, having for its dam a mare and for its sire a jackass. Mules themselves cannot breed. The mule has been for long years the principal draft animal used in the South, and good mules are nearly always in demand at good prices. Texas is as well adapted to successful mule-raising as any other State in the Union. While Texas is far ahead in number of mules, the quality is very low, owing to the use of inferior jacks and small mares for breeding. As mules are used for draft animals they must have weight. Before our mules can take high rank it will be necessary first to breed our small mares to larger size by using pure-bred stallions of heavy type. Then by using the larger mares and selected jacks a better grade of mule will be produced.

QUESTIONS, PROBLEMS, AND EXERCISES

175. Find and score one horse of each type.
176. How many breeds of horses are there in your community and what are they?
177. Plan with the teacher and class a Saturday trip to visit and score each type of horse in your community.
178. Study your references and draw a plan for a good practicable stable for your farm, having place for horses, cows, feed, and harness.

REFERENCES FOR FURTHER READING

"Productive Horse Husbandry," C. W. Gay.
"Types and Breeds of Farm Animals," C. S. Plumb.
"The Horse," I. P. Roberts.

Farmers' Bulletins:
No. 619. "Breeds of Draft Horses."
No. 667. "Colts: Breaking and Training."
No. 779. "How to Select a Sound Horse."
No. 952. "Breeds of Light Horses."
No. 1030. "The Feeding of Horses."
No. 1097. "The Stable Fly."
No. 1146. "Dourine of Horses."

Bureau of Animal Industry, U. S. Department of Agriculture, Bulletins:
No. 3. "Market Classes of Horses."
No. 113. "Classification of American Carriage Horses."
No. 124. "Suggestions for Horse and Mule Raising in the South."
No. 137. "Preservation of Our Native Types of Horses."
No. 138. "Swamp Fever of Horses."
No. 178. "Breeding Horses for the United States Army."

CHAPTER XV

SHEEP

289. **Sheep in America and Texas.**—Sheep were probably among the earliest of domesticated animals, but there were no sheep in North America prior to its settlement by Europeans. They are not grown in Texas in as large numbers as formerly, though the flocks of to-day show great improvement over those of former times. The number of sheep in Texas, January 1, 1910, is given as 1,909,000, and the average price per head as $2.90. The number in Wyoming at the same time is given as 7,136,000, and the average value per head as $4.40. Wyoming ranks first of the States in the Union in point of numbers. In Iowa on the same date the number was only 754,000, but the average value per head was $5.30, the highest of any State in the Union. These figures indicate that Texas, the largest State in the Union, could support a greatly increased number of sheep, and that the quality of sheep in this State should be greatly improved. The latter must be accomplished by the selection of better animals for breeding purposes, and especially by the use of pure-bred rams of high merit. Sheep are well adapted to most sections of Texas where the land is well drained. None of our domestic animals is better adapted to the arid western regions. It would be profitable for nearly every farmer in the State to make the raising of sheep a part of his farming operations.

Sheep afford two sources of income, namely, mutton and wool. They surpass all other farm animals in destroying weeds, thereby making more room for valuable grasses to grow and making use of plants that otherwise would not only be of no value but detrimental.

290. **Judging Sheep.**—*Method of Examination.* In judging sheep it is necessary in examining them to use the hands

Fig. 213. Points of the sheep: 1, muzzle; 2, mouth; 3, lips; 4, nostril; 5, nose; 6, face; 7, forehead; 8, eye; 9, ear; 10, neck; 11, shoulder vein; 12, brisket; 13, top of shoulder; 14, shoulder; 15, chest; 16, foreleg; 17, back; 18, loin; 19, rump; 20, crops; 21, ribs, or side; 22, hip; 23, fore-flank; 24, belly; 25, hind flank; 26, leg of mutton, or thigh; 27, dock; 28, twist; 29, hind leg.
Courtesy of the Agricultural and Mechanical College of Texas.

as well as the eyes on account of the covering of wool hiding the shape. The use of the hands is important also in examining the wool. The best plan is to begin the examination at the head and continue it over the body to the hindquarters and then make a thorough examination of the fleece. In doing this it is very important that the hands be held flat with the fingers together in a sloping position, for in this way it is possible to feel the different parts of the sheep's

body without breaking the fleece. It is objectionable for the fingers to be stuck into the fleece because they make holes in it, thereby giving access to rain and dirt and detracting from the appearance. The illustrations in Figures 215 and

FIG. 214. Mutton cuts on the sheep: 1, leg; 2, loin; 3, short back, or rib; 4, breast; 5, chuck. *Courtesy of the Agricultural and Mechanical College of Texas.*

216 show the correct method of handling sheep in making the examination.

291. **General Classification of Sheep.**—Sheep are divided into two main classes, *mutton sheep* and *fine-wool sheep*. Mutton sheep have been developed primarily for mutton, with wool as a secondary consideration. Fine-woolled sheep have been developed primarily for wool with practically no regard for mutton. We find that the two classes are represented by two distinctly different types.

SCORE-CARD

From Purdue University Circular No. 29

MUTTON SHEEP **FAT**

SCALE OF POINTS	STANDARD	POINTS DEFICIENT	
		STUDENT'S SCORE	CORRECTED
1. AGE	......	......	......
GENERAL APPEARANCE—38 PER CENT			
2. WEIGHT, score according to age	8	......	......
3. FORM, long, level, deep, broad, low set, stylish	10	......	......
4. QUALITY, clean bone; silky hair; fine, pink skin; light in offal; yielding high percentage of meat	10	......	......
5. CONDITION, deep, even covering of firm flesh, especially in regions of valuable cuts. Points indicating ripeness are: thick dock, back thickly covered with flesh, thick neck, full purse, full flank, plump breast	10	......	......
HEAD AND NECK—7 PER CENT			
6. MUZZLE, fine, mouth large; lips thin, nostrils large and open	1	......	......
7. EYES, large, clear, placid	1	......	......
8. FACE, short; features clean cut	1	......	......
9. FOREHEAD, broad, full	1	......	......
10. EARS, fine, alert	1	......	......
11. NECK, thick, short, free from folds	2	......	......
FORE-QUARTERS—7 PER CENT			
12. SHOULDERS, covered with flesh, compact on top; snug	5	......	......
13. BRISKET, neat, proportionate; breast wide	1	......	......
14. LEGS, straight, short, wide apart, strong; forearm full; shank smooth, fine	1	......	......
BODY—20 PER CENT			
15. CHEST, wide, deep, full	4	......	......
16. RIBS, well sprung, long, close	4	......	......
17. BACK, broad, straight, long, thickly fleshed	6	......	......
18. LOIN, thick, broad, long	6	......	......
HIND-QUARTERS—16 PER CENT			
19. HIPS, far apart, level, smooth	2	......	......
20. RUMP, long, level, wide to tail-head	4	......	......
21. THIGHS, full, deep, wide	4	......	......
22. TWIST, plump, deep	5	......	......
23. LEGS, straight, short, strong; shank fine, smooth	1	......	......
WOOL—12 PER CENT			
24. QUALITY, long, dense, even	4	......	......
25. QUALITY, fine, pure; crimp close, regular, even	4	......	......
26. CONDITION, bright, sound, clean, soft, light	4	......	......
Total	100	......	......

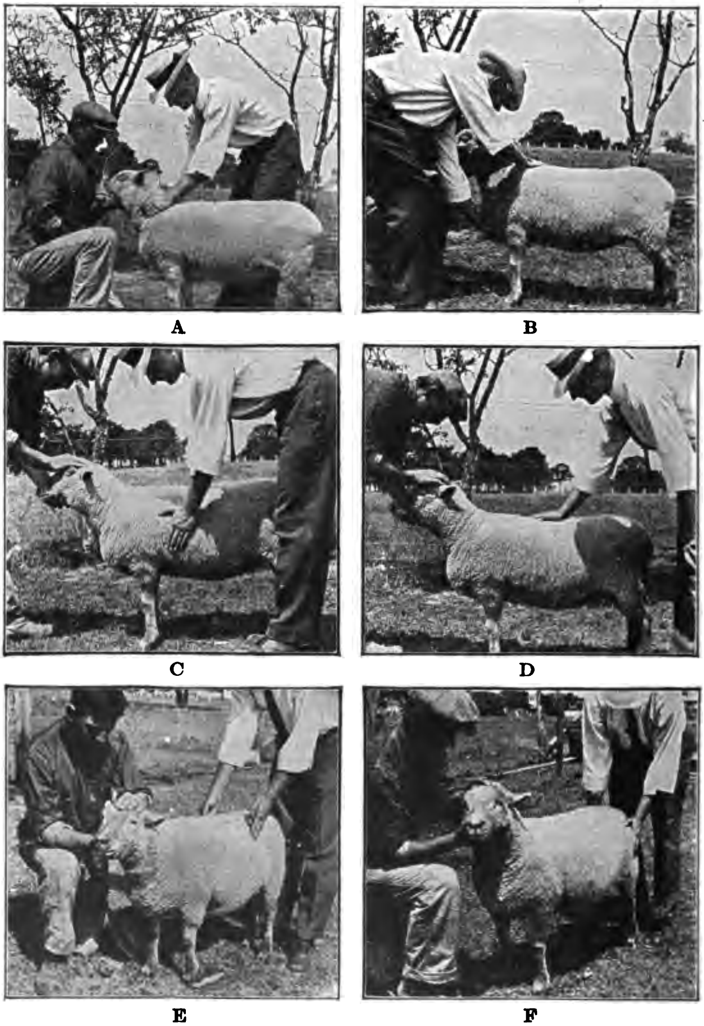

Fig. 215. Judging the sheep. Estimating: *A*, fulness of neck; *B*, depth of chest; *C*, width of chest and covering of ribs; *D*, firmness and covering of back; *E*, width of loin; *F*, width of rump.

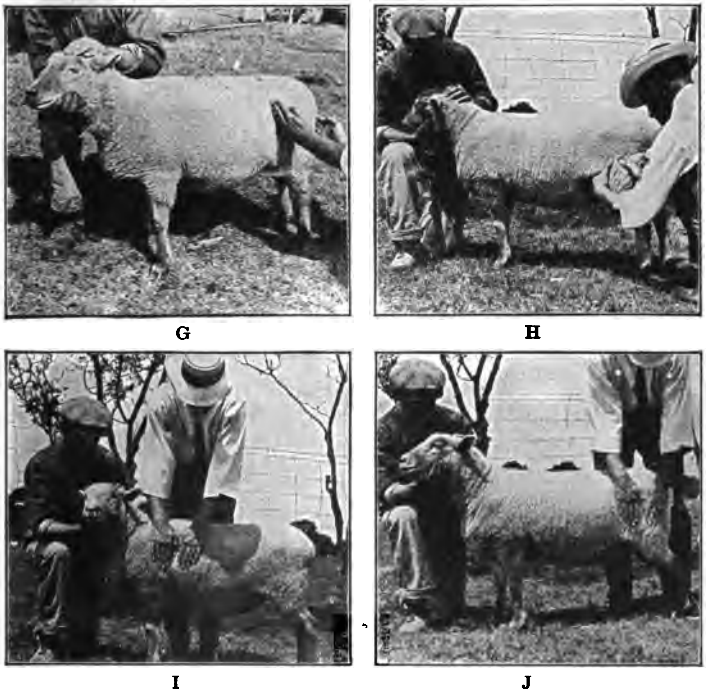

FIG. 216. Judging the sheep. Estimating: *G*, length of rump; *H*, development of leg of mutton; *I*, first quality of wool and examining same; *J*, poorest quality of wool and examining same. *Figures* 215 *and* 216, *courtesy of the Agricultural and Mechanical College of Texas.*

292. **Mutton Sheep.**—Mutton sheep are divided in the same way that beef cattle are divided, into three classes—fat sheep, feeders, and breeders. With the sheep, the hindquarter, loin, and ribs are the parts that produce the high-priced cuts. The score-card and Figures 215 and 216, together with what was said on the steer, make all points plain.

293. **Breeds of Mutton Sheep.**—The breeds of mutton sheep are divided into two classes based on the character of

the wool. The two classes with the breeds included in each are as follows:

MEDIUM-WOOLLED BREEDS	LONG-WOOLLED BREEDS
Southdown	Leicester
Shropshire	Cotswold
Oxford Down	Lincoln
Hampshire Down	
Dorset Horn	
Cheviot	
Suffolk Down	
Tunis	

Southdown. The native home of the Southdown breed is in the county of Sussex, England, the original stock being the native sheep of Sussex. The breed gets its name from the low range of chalky hills, known as the South Downs, which extend through the county. With its low-set, thick, smooth, plump form and high quality no breed of sheep excels the Southdown for mutton. It is also noted for its hardy character. Southdown sheep are not heavy wool producers and lack in size. Mature rams average about one hundred and seventy-five pounds and mature ewes one hundred and thirty-five pounds. The average clip of wool per year for ewes is about six or seven pounds. Rams average a little higher. The color of the face, ears, and legs of the Southdown is grayish or reddish brown. They have wide adaptability and are justly popular.

Shropshire. This breed of sheep originated in Shropshire and Staffordshire, England. The Shropshire is larger than the Southdown and produces a considerably heavier fleece. Mature rams average about two hundred and twenty-five pounds and ewes about one hundred and sixty pounds in weight. Ewes average from eight to ten pounds of wool per year and rams twelve to fifteen. The face, ears, and legs

are usually dark brown or blackish brown. A distinguishing feature of the best specimens of the breed is the covering of wool over the head and face, leaving only a small space bare around the mouth and nostrils. The ears should

FIG. 217. Wether in fleece.
Courtesy of Professor W. C. Coffey.

be covered with fine wool instead of hair, and the legs should be well covered with wool down to the feet.

Oxford Down. The native home of this breed is Oxford County, England. It has a mixture of Southdown, Hampshire, and Cotswold blood. It is the largest of the medium-woolled breeds. Mature rams weigh from two hundred and seventy five to three hundred pounds, while ewes weigh about two hundred pounds. The Oxford Down is also in the first rank in the amount of wool produced. A good flock should

average about twelve pounds of wool per year. Sheep of this breed are not so heavily woolled over the head as the Shropshire, and the fleece is longer and more open. The color of the face and legs is a lighter brown than that of the

FIG. 218. Wether shorn.
Courtesy of Professor W. C. Coffey.

Shropshire. On account of their large size and heavy fleece they have gained considerable favor in this country.

Hampshire Down. This is also an English breed, originated by crossing Southdown rams on native ewes. It is next to the Oxford Down in size, but only medium in production of wool. The wool is not of high quality. There are many Hampshires in Texas, and they seem to be well suited to this region. They have the highly desirable quality of dropping their lambs very early, earlier than any other mutton breed except the Dorset Horn.

Dorset Horn. It is thought that this breed originated through the careful selection of breeding animals from native stock that existed in Dorset and surrounding counties in England. The other breeds of sheep that have been discussed are hornless, but this breed, in the case of both males and females, has horns. The color of the face, nostrils, legs, and hoofs is white. The head should have a short foretop of wool. The body should be well covered with wool, which should extend down to the knees and hocks. In size the Dorset Horn ranks as medium among the medium-woolled breeds. Mature rams average about two hundred and twenty-five pounds, and mature ewes one hundred and sixty-five pounds. As a wool producer the breed does not rank high. Mature rams average about nine pounds and mature ewes about six pounds of unwashed wool. The breed is especially noted for the production of early lambs and for the good milk-producing qualities of the ewes, making them especially good mothers. Several high-class flocks are now owned in this country, chiefly in the Northeastern States. The fact that the ewes can be bred to drop lambs at practically any time of the year should do much to make the breed popular in this country, especially in the South.

Long-Woolled Breeds. The long-woolled breeds of mutton sheep are better suited to colder climates and hence are more popular in Canada than Texas. The *Lincoln* is the largest of all breeds of sheep, the rams averaging three hundred pounds in weight and the ewes two hundred and seventy-five pounds. The fleece of rams weighs eighteen to twenty pounds and of ewes about fifteen pounds. The wool is noted for its length and lustre. The *Cotswold* is next in size, with a fleece eight inches long and weighing about ten pounds.

The *Leicester* is the smallest of the long-woolled sheep, but has a fleece about the same weight as the Cotswold. The fleece of the long-woolled sheep is more open than that of the medium-woolled varieties.

294. **Fine-Woolled Sheep.**—The Merino or fine-woolled type of sheep possesses a type of body closely resembling that of the dairy cow. Instead of being full and square of form as is the mutton type, the Merino type is rather muscular and angular. The production of a heavy, dense fleece of fine quality, evenly distributed over the whole body, is the primary consideration in breeding Merino sheep. Spain is the native land of the Merino, but all the improved breeds are from other countries. The score-card gives points in detail to be considered in judging sheep of this type.

FIG. 219. A good mutton type.
Courtesy of Professor W. C. Coffey.

295. **Breeds of Fine-Woolled Sheep.**—Fine-woolled sheep in the United States are chiefly represented by three breeds, American Merino, Delaine Merino, and Rambouillet.

American Merino. This breed is simply an improved type of Spanish Merino, improved chiefly in this country. In size the American Merino varies considerably. Mature rams weigh from one hundred and thirty to over one hundred and fifty pounds, ewes average about one hundred pounds. Sheep of this breed stand in the front rank as to weight and quality

SCORE-CARD

From "Judging Live Stock," by J. C. Craig.

FINE-WOOLLED SHEEP **MARKET**

SCALE OF POINTS	STANDARD	POINTS DEFICIENT: STUDENT'S SCORE	POINTS DEFICIENT: CORRECTED
GENERAL APPEARANCE			
FORM, level, deep, stylish, round rather than square	8	......	......
QUALITY, clean, fine bone; silky hair; fine skin	6	......	......
HEAD AND NECK			
MUZZLE, fine; broad, wrinkly nose; pure white	1	......	......
EYES, large, clear, placid	1	......	......
FACE, wrinkly, covered with soft, velvety coat	1	......	......
FOREHEAD, broad, full	1	......	......
EARS, soft, thick, velvety	1	......	......
NECK, short, muscular, well set on shoulders	1	......	......
FORE-QUARTERS			
SHOULDER, strong, being deep and broad	4	......	......
BRISKET, projecting forward, breast wide	1	......	......
LEGS, straight, short, wide apart; shank smooth and fine	2	......	......
BODY			
CHEST, deep, full, indicating constitution	10	......	......
BACK, level, long; round ribbed	4	......	......
LOIN, wide, level	4	......	......
FLANK, low, making underline straight	2	......	......
HIND-QUARTERS			
HIPS, far apart, level, smooth	2	......	......
RUMP, long, level, wide	4	......	......
LEGS, straight, short, strong; shank smooth, fine	2	......	......
WOOL			
KIND—Domestic, clean and bright. Territory, dirty or discolored. Carpet / Blanket } Hairy or having dead fibres.			
CLASS—Clothing, fibre under two inches in length or unsound. Delaine, fibre two or three inches in length. Combing, fibre over three inches in length and sound.			
GRADE—Fine, medium, or coarse.			
QUANTITY—Long, dense, even covering, especially over crown, cheek, armpit, hind legs, and belly	15	......	......
QUALITY—Fine fibre, crimp close, regular; even quality including tops of folds	15	......	......
CONDITION—Bright, lustrous, sound, pure, soft, even distribution of yolk, with even surface to fleece	15	......	......
Total	100	......	......

of fleece and strength of fibre. Mature rams shear about twenty pounds and ewes from twelve to fifteen pounds of unwashed wool. One two-year-old ram in Vermont sheared forty-four pounds three ounces. The length of the fleece of one year's growth is about two and one-half inches. The American Merino is characterized by heavy folds or wrinkles over the whole body except the back. This feature is much more pronounced than in the other fine-woolled breeds. The fleece covers the entire body and legs, leaving only the nose and ears bare. All of the fine-woolled breeds carry a much larger amount of oil or yolk in their fleeces than do the mutton breeds, but the American Merino carries more than any other breed. After a fleece of this breed has been scoured it may show a shrinkage in weight as high as sixty-five per cent. American Merino rams have large spirally twisted horns. The ewes are hornless. The large range flocks of Texas and other States of the West and Southwest were made up at one time largely of American Merinos. The breed is less popular now, partly on account of the increasing demand for mutton and partly because of the demand for a type of sheep with fewer folds on the body, so that shearing may be less difficult.

Delaine Merino. The Delaine Merino is a branch of the American Merino that has been developed especially in Ohio. The Delaine differs from the American Merino in the following ways: It is usually larger, is more thickly fleshed, thus making better mutton; is practically free of folds except about the neck; the fibre is longer, growing from three to five inches a year, but the fleece weighs less, partly on account of having less oil in it; the rams may or may not have horns, the ewes are hornless. Delaine Merinos have

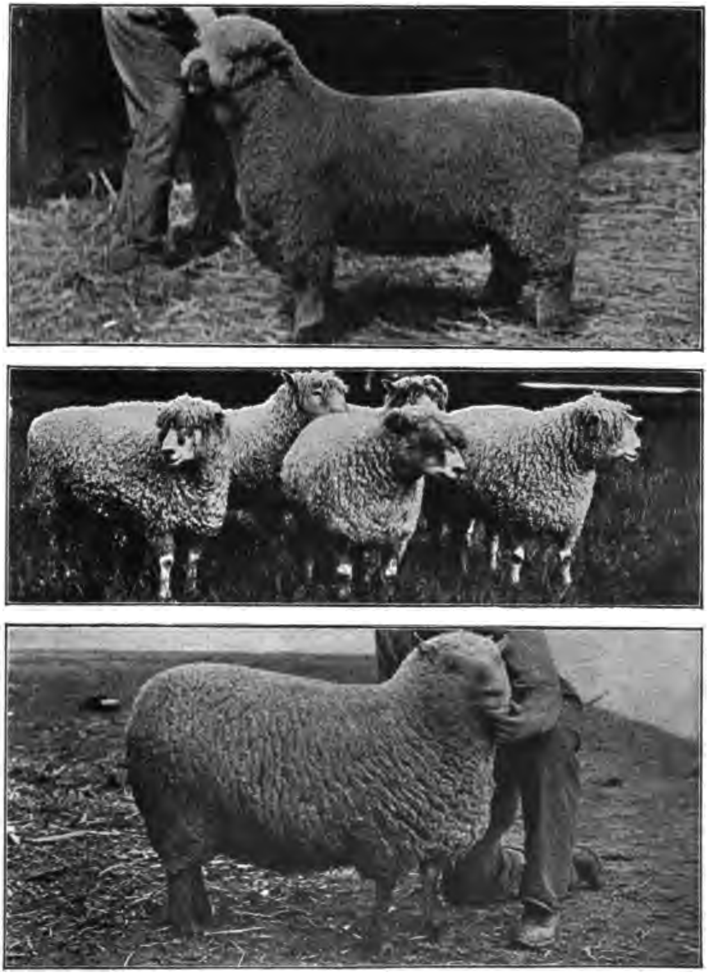

Fig. 220. Mutton sheep: above, Shropshire ram lamb; centre, Cotswold rams; below, Southdown ewe.

Courtesy of Professor W. C. Coffey.

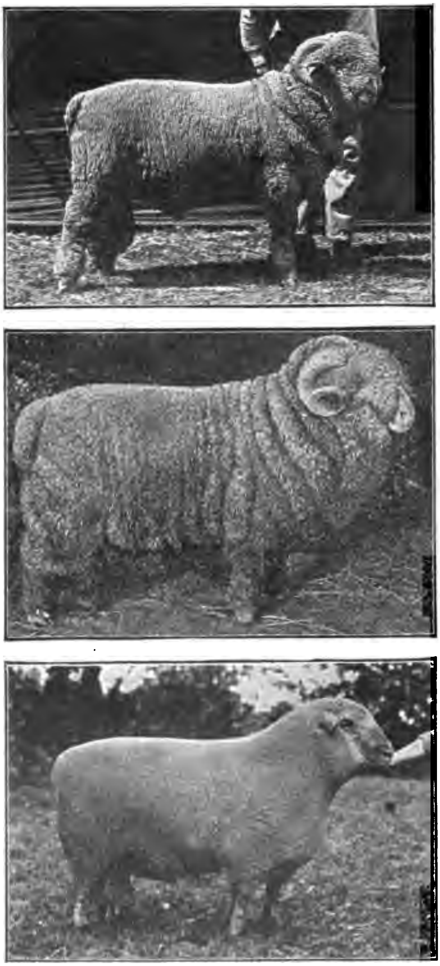

FIG 221. Rambouillet ram above, Delaine ram in centre, Hampshire ram below.
Courtesy of Professor W. C. Coffey.

become widely distributed in the United States. Rams of this breed have been used extensively in the range flocks of the West and Southwest.

Rambouillet. The native home of the Rambouillet is in France. In 1783 the French government purchased a large farm near the village of Rambouillet for the purpose of developing an improved type of fine-woolled sheep. It is from this village that the breed gets its name. The Rambouillet is the largest of the fine-woolled breeds. The average weight of mature rams is about one hundred and eighty-five pounds and of mature ewes one hundred and fifty to

one hundred and sixty pounds. Mature rams shear on the average about ten pounds of wool per year. The fleece of the breed is not quite as fine as that of the other fine-woolled breeds and does not contain as much oil. The length for one year's growth is about three inches. In mutton qualities the Rambouillet is the best of the fine-woolled sheep. Folds occur usually only on the neck and breast. Rams usually have large spirally twisted horns, though some are hornless. The ewes are hornless. Wool covers the entire body and legs, leaving only the nose and ears bare. Numerous importations have been made into the United States and to-day the breed is extensively distributed throughout the country. On account of the ease with which it is sheared and its fairly good mutton qualities it has gained much favor in the West and Southwest, where the rams are used extensively.

Goats

296. **Uses of the Goat.**—Goats are valued chiefly for the production of fleece called *mohair,* and for the production of milk and mutton. There have been no strains or breeds of goats developed primarily for mutton production. Though goat meat is used to some extent, the flesh of kid or young goat especially being of good quality and flavor, it has never become popular. Several breeds of milk goats have been developed in various countries, notably on the island of Malta, in Switzerland, Germany, Egypt, Abyssinia, and South Africa. In the United States milk goats have not come into much favor, though in recent years a number of importations have been made. The breed of goats most

popular in the United States is the Angora, which has been developed primarily for its mohair.

The Angora Goat. The native home of this goat is in the district of Angora, in Asia Minor. It is very probable that it has inhabited this region since before the Christian era. The Angora is adapted to a wide range of conditions, but seems to thrive best in a rather dry climate. Texas, New Mexico, and other Southwestern States are particularly well adapted to the raising of Angoras, and are noted for large flocks of both pure breds and grades.

FIG. 222. Angora buck.
Courtesy of Mr. J. V. Hardy.

Being browsers by nature and not grazing animals, they are very effective in destroying tree-sprouts from "cut-over" land and brush and undergrowth of all kinds. They are used extensively to keep down undergrowth.

The Angora is smaller than the common goat, weighing usually from sixty to one hundred pounds. The back should be straight, shoulders and hips equal height, chest broad, body round, legs short and strong, head clean cut, eye bright, and muzzle broad. Avoid sloping rump, drooping head, and pinched nostril. The ears may be six to eight inches long and pendant or short and pointed. The fleece should be pure white, and should cover the entire body up to the ears and jaw. The mohair should grow to the length of about ten inches during a year, and should hang in tight ringlets or

wavy curls that extend entirely to the skin. The fleece usually weighs about three pounds, though many flocks average four or four and a half pounds. Occasionally animals produce heavier fleeces. The Angora sheds its fleece each spring if not shorn. On this account it is necessary in the South to shear rather early in the spring, usually during March. If care is not taken to prevent goats from getting wet for five or six weeks after shearing they often contract colds and heavy losses result.

QUESTIONS, PROBLEMS, AND EXERCISES

179. How many sheep are raised on your farm and what breeds are they?
180. How many sheep could be raised on your farm without interfering with the crops now raised?
181. Make a plan for a small beginning in sheep-raising on your farm, finding exactly what this would cost and estimating the probable returns.
182. What other advantages not mentioned in the text are there in sheep-raising? What are the difficulties in the way in your locality?
183. What difficulties are there on your farm in the way of raising goats?
184. Find from your references the best methods of caring for and protecting sheep and explain these to the class.
185. If each sheep consumes 500 pounds of roughage, 50 cents' worth of pasture, and four bushels of oats a year, and produces seven pounds of wool and one lamb, what, at the prices in your community, will a farmer gain or lose on a flock of 100 sheep?

REFERENCES FOR FURTHER READING

"Productive Sheep Husbandry," E. Y. Coffee.
"Sheep Management, Breeds and Judging," Frank Kleinheinz.
"Types and Breeds of Farm Animals," C. S. Plumb.

Farmers' Bulletins:
No. 576. "Breeds of Sheep for the Farm."
No. 713. "Sheep Scab."

No. 798. "The Sheep Tick and Its Eradication by Dipping."
No. 810. "Equipment for Farm Sheep Raising."
No. 840. "Farm Sheep Raising for Beginners."
No. 920. "Milk Goats."
No. 1134. "Castrating and Docking Lambs."
No. 1150. "Parasites and Parasitic Diseases of Sheep."
No. 1155. "Diseases of Sheep" (Infectious and Non-infectious).
No. 1172. "Farm Slaughtering and Use of Lamb and Mutton."
No. 1181. "Raising Sheep on Temporary Pastures."
No. 1199. "Judging Sheep."
No. 1203. "The Angora Goat."
No. 1268. "The Sheep-Killing Dog."

Texas Experiment Station Bulletins:
No. 205. "Sheep Breeding and Feeding."
No. 232. "Mineral Requirements of Sheep."
Nos. 269, 285. "Grain Sorghums *vs.* Corn for Fattening Lambs."

CHAPTER XVI

HOGS

297. **Importance of the Hog Industry in Texas.**—Hogs should be one of the most important factors in diversified farming. Very few farms are complete without them, especially in the Southwest. As a rule the farmer who does not count them as one of his principal crops does not realize from his farm what it is capable of yielding him. Not only can the farmer through raising hogs often produce his own meat supply, by feeding what would otherwise be wasted, but he can market much of his grain and forage crops more profitably when converted into pork and lard than in any other form. The hog is excelled only by the dairy cow in economy in converting foodstuff into an animal product for use as food by man. The number of hogs in Texas January 1, 1910, was reported to be 3,205,000, and the average price per head was $6.60. Iowa ranks first in number of hogs, having 6,485,000, valued at $11.30 each. Rhode Island and Connecticut rank first in point of value per head, this being in these States $12.50. Texas ranks third in numbers, but in the average price per head her rank is very low. In many respects Texas is better adapted to successful hog-raising than Iowa. Our farm-

ers can grow successfully not only corn and other grains suited to hogs, but they can grow also different kinds of green forage crops practically throughout the year. These green forage crops which hogs may graze and harvest themselves

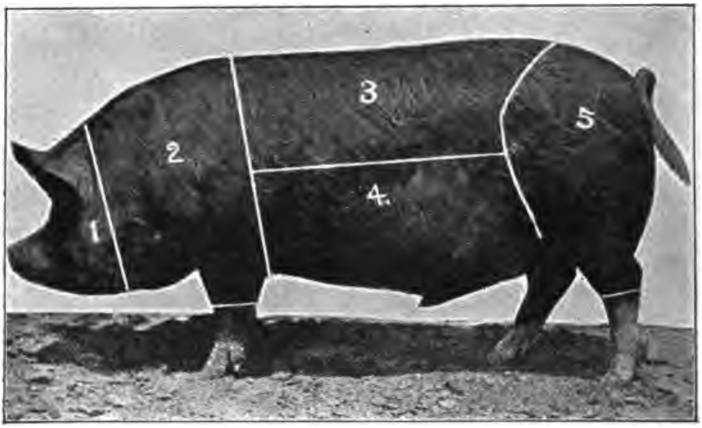

FIG. 223. Wholesale pork cuts located on the live animal: 1, head; 2, shoulder; 3, loin; 4, belly; 5, ham. Pure-bred Berkshire barrow.
From Purdue University Circular No. 29.

are among the most important factors in the economical production of pork. Hence, with her natural advantages Texas could easily rank first as a hog-raising State both in respect to numbers and value per head. In order to do this, however, Texas farmers must give more attention to the selection of good breeding stock and must learn to feed and care for their hogs better. In all cases only good, pure-bred males of the chosen breed should be used. The scrub and grade male should be sent to the butcher's block. The cost of a pure-bred boar is so small that there is no excuse for breeding scrub hogs. The pure breds and grades not only grow to larger

size, but mature earlier and have weight in those parts of the body that furnish the high-price cuts. The demand for ham, bacon, lard, and other hog products is steadily increasing, and with proper management a good margin of profit exists in producing hogs for the market. The meat that is used at

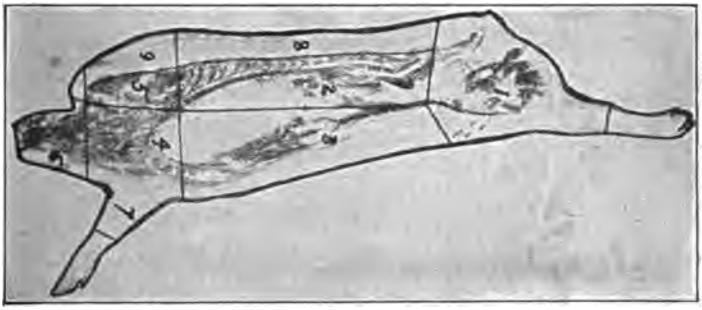

FIG. 224. Wholesale pork cuts: 1, short-cut ham; 2, loin; 3, belly; 4, picnic butt; 5, Boston butt; 6, jowl; 7, hock; 8, fat back; 9, clear plate; 2, 3, 8, side; 2, 8, back; 4, 7, picnic shoulder; 5, 9, shoulder butt; 8, 9, long fat back; 4, 5, 7, 9, rough shoulder.

From Purdue University Circular No. 29.

home can be produced on the farm much more cheaply than it can be bought.

298. **The Care of Hogs.**—Hogs are healthier and can be raised much more economically if they live partly on pasture and green crops than when kept in pens all the time and fed. They should usually have a little grain to balance their ration properly, but by growing such crops as alfalfa, clover, peas, soy-beans, vetch, sorghum, and pea-nuts for hogs the cost of pork is greatly reduced. A part of these crops may be harvested by the hogs themselves.

As the hog makes greater gain per hundred pounds of food consumed when it is young than when it is grown, it is usually

more profitable to grow them rapidly and sell before they are a year old.

Sows need attention, especially at farrowing time, and should be protected against the weather, and the pigs should be protected against the stupidity and awkwardness of the mother.

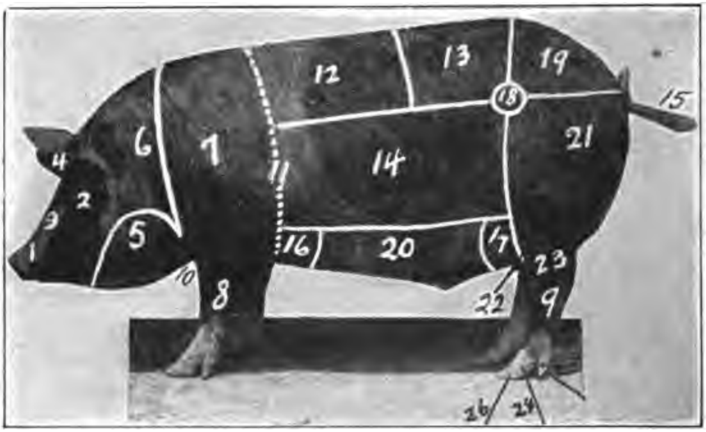

Fig. 225. Points of the hog: 1, snout; 2, eye; 3, face; 4, ear; 5, jowl; 6, neck; 7, shoulder; 8, foreleg; 9, hind leg; 10, breast; 11, chest line; 12, back; 13, loin; 14, side; 15, tail; 16, fore flank; 17, hind flank; 18, hip; 19, rump; 20, belly; 21, ham; 22, stifle; 23, hock; 24, pasterns; 25, dew-claw; 26, foot.
From Purdue University Circular No. 29.

The little cot shown in the cut offers one easy and inexpensive means of meeting these needs. Further suggestions should be looked up in your references.

Hog cholera, which for so many years was such a scourge, has now been conquered by the scientists, so that its ravages may be checked by making the hogs immune through a form of inoculation. Whenever hog cholera appears, notice should at once be sent to the Agricultural and Mechanical College

SCORE-CARD

From Purdue University Circular No. 29

FAT HOGS **MARKET**

SCALE OF POINTS	STANDARD	POINTS DEFICIENT	
		STUDENT'S SCORE	CORRECTED
GENERAL APPEARANCE—30 PER CENT			
1. WEIGHT, score according to age	4	......	......
2. FORM, deep, broad, medium length; smooth, compact, symmetrical; standing squarely on medium short legs	10	......	......
3. QUALITY, hair smooth and fine; bone medium size, clean, strong; general appearance smooth and refined	6	......	......
4. COVERING, finished; deep, even, mellow, free from lumps and wrinkles	10	......	......
HEAD AND NECK—8 PER CENT			
5. SNOUT, medium length, not coarse	1	......	......
6. EYES, not sunken, clear, not obscured by wrinkles	1	......	......
7. FACE, short; cheeks full	1	......	......
8. EARS, fine, medium size, attached neatly	1	......	......
9. JOWL, full, firm, neat	2	......	......
10. NECK, thick, short, smooth to shoulder	2	......	......
FORE-QUARTERS—12 PER CENT			
11. SHOULDERS, broad, deep, smooth, compact on top	8	......	......
12. BREAST, full, smooth, neat	2	......	......
13. LEGS, straight, short, strong; bone clean, hard; pasterns short, strong, upright; feet medium size	2	......	......
BODY—33 PER CENT			
14. CHEST, deep, wide, large girth	4	......	......
15. SIDES, deep, full, smooth, medium length	8	......	......
16. BACK, broad, strongly arched, thickly and evenly covered	9	......	......
17. LOIN, wide, thick, strong	9	......	......
18. BELLY, straight, smooth, firm	3	......	......
HIND-QUARTERS—17 PER CENT			
19. HIPS, wide apart, smooth	3	......	......
20. RUMP, long, level, wide, evenly fleshed	3	......	......
21. HAM, heavily fleshed, full, firm, deep, wide	9	......	......
22. LEGS, straight, short, strong; bone clean, hard; pasterns short, strong, upright; feet medium sized	2	......	......
Total	100	......	......

SCORE-CARD

From "Judging Live Stock," by J. A. Craig

BACON HOGS **MARKET**

SCALE OF POINTS	STANDARD	POINTS DEFICIENT: STUDENT'S SCORE	POINTS DEFICIENT: CORRECTED
GENERAL APPEARANCE			
WEIGHT, 170 to 200 lbs., largely the result of thick cover of firm flesh	6	......	......
FORM, long, level, smooth, deep	10	......	......
QUALITY, hair fine; skin thin; bone fine; firm, even covering of flesh without any soft bunches of fat or wrinkles	10	......	......
CONDITION, deep, uniform covering of flesh, especially in regions of valuable cuts	10	......	......
HEAD AND NECK			
SNOUT, fine	1	......	......
EYES, full, mild, bright	1	......	......
FACE, slim	1	......	......
EARS, trim, medium size	1	......	......
JOWL, light, trim	1	......	......
NECK, medium length, light	1	......	......
FORE-QUARTERS			
SHOULDERS, free from roughness, smooth, compact, and same width as back and hind-quarters	6	......	......
BREAST, moderately wide, full	2	......	......
LEGS, straight, short, strong, bone clean; pasterns upright; feet medium size	2	......	......
BODY			
CHEST, deep, full girth	4	......	......
BACK, medium and uniform in width, smooth	8	......	......
SIDES, long smooth, level from beginning of shoulders to end of hind-quarters. The side at all points should touch a straight edge running from fore to hind quarter	10	......	......
RIBS, deep	2	......	......
BELLY, trim, firm, thick, without any flabbiness or shrinkage at flank	10	......	......
HIND-QUARTERS			
HIPS, smooth, wide; proportionate to rest of body	2	......	......
RUMP, long, even, straight, rounded toward tail	2	......	......
GAMMON, firm, rounded, tapering, fleshed deep and low toward hocks	8	......	......
LEGS, straight, short, strong; feet medium size; bone clean; pasterns upright	2	......	......
Total	100	......	......

and the help of an expert secured to eradicate it. In order to prevent disease getting a hold or spreading among hogs several precautions should be taken. First, any newly bought hog should be kept to himself for several days before being put with the other hogs; second, hogs should not be

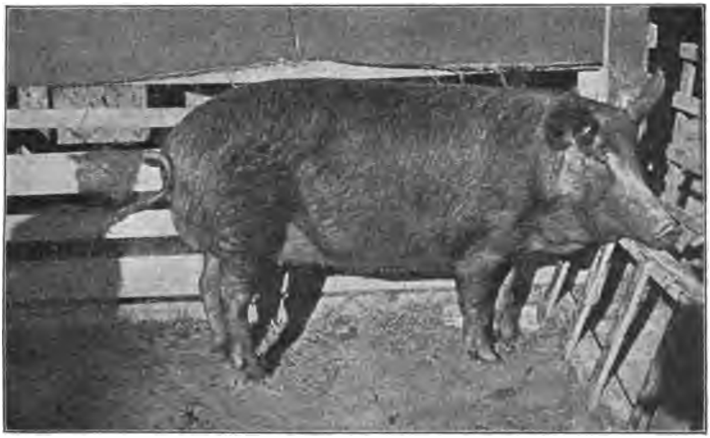

FIG. 226. The bacon type. Champion yearling Tamworth sow. *Courtesy of "Farm and Ranch."*

allowed to drink water that may be contaminated. Running streams often carry infection into a farm; third, hogs should not be kept together in large herds, but in small herds separated from one another.

299. **Judging Hogs.**—Hogs are divided into two general classes: *fat* or *lard hogs* and *bacon hogs.*

Fat Hogs supply the market's demand for lard, well-developed hams and shoulders, broad, fat backs, broad, thick loins, and thick side meat. Such hogs necessarily have a deep, wide, thick form of medium length and short legs. The

best fat hog is one which will produce the highest per cent of dressed carcass of the best quality. This is the hog for which the butcher or packer will pay the highest price. The score-card on page 389 gives in detail the points to be considered in judging fat hogs.

Bacon Hogs. The bacon hog is comparatively narrow and upright in form, rather light in hams and shoulders, but long and deep in the sides. This type of hog supplies the market with bacon of the best quality. The points to be considered in judging bacon hogs are given in the score-card on page 390.

Hogs for Breeding Purposes. In judging hogs for breeding purposes the same points must be kept in mind as in judging all other breeding animals. The animal must, in addition to being good from the market stand-point, be a typical representative of its breed, show evidence of a strong constitution, and the characteristics of its sex. The sow should have twelve fully developed teats and should be somewhat longer of body than the boar of the same breed. It is especially important that she possess a gentle yet active disposition, as a wild, nervous, or sluggish sow is liable to injure her pigs.

300. **Breeds of Fat Hogs.**—The principal breeds of fat hogs are the Berkshire, Poland-China, Duroc-Jersey, Chester White, Essex, Cheshire, Victoria, and Small Yorkshire.

Berkshire. England is the native home of this breed of hogs. The Berkshire of to-day is characterized by a rather long body, short, dished face, and medium-sized, pointed, erect ears. The color is black, with white on face, feet, and tip of tail. White spots sometimes occur on the body, and though objectionable, they do not indicate impurity of breed.

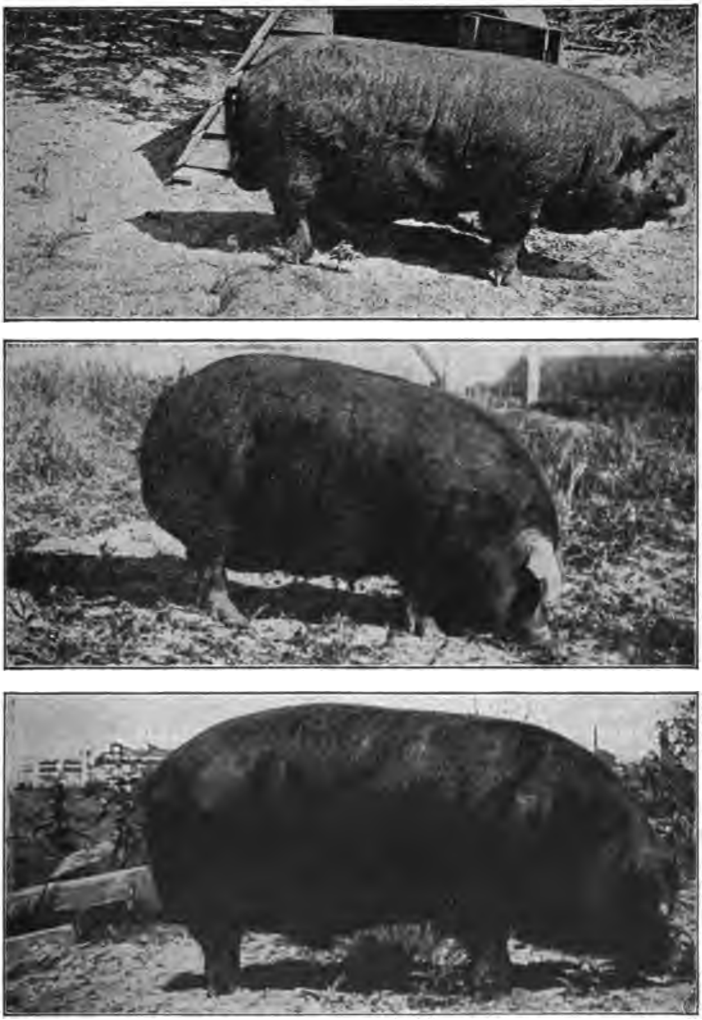

Fig. 227. The lard or fat hog type: above, a Berkshire boar; in centre, a Poland-China sow; below, a Duroc-Jersey boar.

Courtesy of the Agricultural and Mechanical College of Texas.

In size, hogs of this breed rank from medium to large. Mature boars in breeding condition average about five hundred pounds and mature sows about four hundred pounds. Many individuals weigh much more. The breed is adapted to a very wide range of conditions and to-day is one of the most widely distributed breeds in the United States. It has proved to be well adapted to Southern conditions, and in Texas is one of the most popular breeds.

Poland-China. This breed of hogs originated in the United States, chiefly in Ohio during the period between 1825 and 1840. The modern type of Poland-China shows much quality and a decidedly thick, low-set form of medium length. The head is broad and of medium length and the face is practically straight. The ears should be of medium size and fine and the top third should droop. The color is generally black, with white on face, feet, and tip of tail. White spots on the body are not uncommon, however. In size the Poland-China holds about the same rank as the Berkshire. Some breeders have bred for a much larger type than have others. This breed has become widely distributed in the United States, and has met with special favor in the corn-belt region on account of its easy fattening and early maturing qualities. It is well adapted to the South, and in Texas has long been very popular.

Duroc-Jersey. This American breed of hogs had its origin in the combination of the large, coarse Jersey Red of New Jersey with the finer red Duroc breed of New York. The breeders of these two breeds decided on a definite standard for the Duroc-Jersey in 1877. The best breeders of other red hogs soon afterward adopted the Duroc-Jersey standard and a systematic development of the breed followed. The

Duroc-Jersey of to-day resembles the Poland-China to a considerable degree except in color. The head is wide and of medium length and the face is only slightly dished. The ears are of medium size, the upper third droops forward. The color varies from a light or yellowish red to a cherry red,

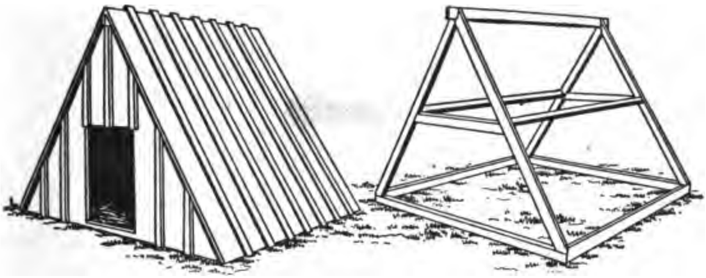

FIG. 228. Wigwam hog cot used at the Wisconsin Station.
Courtesy of the U. S. Department of Agriculture.

the latter being in greatest favor. In size the Duroc-Jersey ranks among the largest of the fat-hog breeds. Mature boars in good condition should average about six hundred pounds, and mature sows about five hundred. The breed is widely distributed in the United States, and has gained much favor. It is well adapted to the South, and in Texas is one of the most popular breeds.

Chester White. This breed originated in Chester County, Pennsylvania, about the beginning of the nineteenth century. It resulted from crossing a white hog common in that region known as the Big China with some white hogs of Yorkshire descent. This breed also resembles the Poland-China except in color, and is about the same weight. In the Eastern and corn-belt States the Chester White has long been held in high favor. It is not so well adapted to Southern con-

ditions as the Berkshire, Poland-China, and Duroc-Jersey, on account of its color. The long, hot summers of the South cause the skin to sun-scald and become scurfy.

The Essex, Cheshire, Victoria, and *Yorkshire* breeds are not widely distributed in America.

301. **Breeds of Bacon Hogs.**—The breeds of bacon hogs are the Tamworth, the Large Yorkshire, and the Hampshire.

The Tamworth is one of the oldest English breeds of hogs. Since the early part of the nineteenth century it has been improved through careful selection and without any infusion of foreign blood. The result is that to-day representatives of the breed are very uniform in type and color. Tamworths are decidedly of the bacon type, being long and deep of body and lacking the width which characterizes the fat-hog breeds. The head is long of snout, the face is slightly dished, and the ears are rather large and carried erect or tilted slightly forward without drooping. The color varies from a dark to a light shade of red, a cherry red being preferred. In size the breed is of the first rank. Mature boars average six hundred pounds and mature sows four hundred and fifty pounds. Some boars weigh as much as one thousand pounds. Tamworths are very hardy and are industrious in seeking food. The sows are noted for being prolific breeders. The breed is popular in Canada, where there is a greater demand for the bacon type of hog than in the United States. The Tamworth is well adapted to the South and is growing in favor here. Several good herds are owned in Texas.

Large Yorkshire. This breed of hogs originated in England. It is quite uniform in type, with a long, deep body of medium width, making it well suited to bacon production.

The head is of medium length, the face somewhat dished, and the ears, though often inclined to droop, should be carried erect. The hair is white and the skin pink, with an occasional bluish or black spot. In size the Large Yorkshire is

FIG. 229. These pigs are litter mates. The larger one is the boy's, the smaller one his father's. Good stock is necessary for best results, but good stock must have good care and feeding.

Courtesy of "Farm and Ranch."

one of the largest breeds of hogs. Mature boars usually weigh from six hundred to seven hundred pounds and mature sows from four hundred and fifty to six hundred. The boar occasionally weighs over a thousand. In Canada this is the leading breed of hogs. It is popular also in a few of the Northern States. A few Yorkshires are owned in

Texas, but they are not well adapted to this and other Southern States on account of their color.

Hampshire. This breed, which was formerly called the *Thin Rind,* on account of its thin skin and soft, silky hair, has been bred for many years in Kentucky, Indiana, and Illinois. While it is raised in other States, including Texas, it has never become widely popular. A striking feature of the breed is a white belt from four to twelve inches wide encircling the black body about the shoulders and foreribs. In size this breed is medium.

QUESTIONS, PROBLEMS, AND EXERCISES

186. How much meat is bought per year on your farm, and how much does it cost?
187. How many hogs would it be necessary to raise per year to supply the meat needed on your farm, and how many acres of land would be required to feed the hogs?
188. Find out how much a young boar and young sows of the leading breeds cost in your community, and figure the expense of starting a small pure-bred or grade herd.
189. If it were true that a slow-growing scrub would give as large a carcass per hundred pounds of food consumed as a pure-bred hog, what would still be the advantages in raising pure-bred or high-grade hogs?
190. Get your father to let you feed and care for a litter of pigs. Keep an exact account of all food used, and find what it costs per pound to produce this meat. Charge all home-raised food at its market value and all bought food at cost.
191. What foodstuff is wasted on your farm that could be eaten by hogs?
192. Is there idle land on your farm on which crops could be grown easily for feeding hogs?

REFERENCES FOR FURTHER READING

"Pork Production," W. A. Smith.
"Success with Hogs," Charles Dawson.

Farmers' Bulletins:

No. 438. "Hog Houses."
No. 614. "A Corn-Belt Farming System which Saves Harvest Labor by Hogging Down Crops."
No. 780. "Castration of Pigs."
No. 781. "Tuberculosis of Hogs."
No. 834. "Hog Cholera."
No. 874. "Swine Management."
No. 906. "The Self-Feeder for Hogs."
No. 951. "Hog Pastures for the Southern States."
No. 966. "A Simple Hog-Breeding Crate."
No. 985. "Systems of Hog Farming in the Southeastern States."
No. 1018. "Hemorrhagic Septicemia, Stockyard Fever, Swine Plague, Fowl Cholera, etc."
No. 1085. "Hog Lice and Hog Mange."
No. 1186. "Pork on the Farm: Killing, Curing, and Canning."

The A. and M. College of Texas Extension Service Bulletins:

No. B-52. "Hogs in Texas."
No. C-12. "Feeding and Care of the Brood Sow and Litter."

Texas Experiment Station Bulletins:

No. 224. "The Influence of Pea-nuts and Rice Bran on the Quality of Pork."
No. 226. "Co-operative Soft Pork Investigations."
No. 228. "The Influence of Pea-nut Meal on Quality of Pork."
No. 242. "Hardening of Pea-nut-Fed Hogs."

CHAPTER XVII

POULTRY

302. **Poultry in the United States.**—On most farms the raising of poultry is a side issue to which little intelligent attention is given. Each year, however, more farmers are realizing that poultry is one of the best-paying farm products. In the amount of human food that they supply per acre, chickens are surpassed only by the dairy cow. In many cases the money returns are much greater from poultry than from the dairy. The total poultry production of the United States in 1920 was valued at $1,250,000,000, while that of Texas was estimated at $43,303,000 for the same year. Texas ranks first in production of turkeys and fifth in total poultry production in the United States.

303. **Texas and the South Well Suited to Poultry-Raising.**—The mild winters and the comparatively dry climate of Texas and of most of the South are highly favorable to poultry-raising. The fowls can exercise in the open and secure fresh, green foods almost every day in the year, which greatly promotes both growth and egg-laying, and lessens the cost of housing and feeding. Only a reasonable amount of intelligent care is needed to increase vastly the value of the poultry products of this section.

304. **Advantages of Poultry on the Farm.**—The fowls on a farm bring probably a greater net profit above the cost of

production than any other animal or crop, because usually they range widely and feed largely on grass, weed-seed, bugs, and insects injurious to the crops. Such additional feed as they need can be provided through waste from the garden and crib and through inexpensive crops raised for their support. The fact that poultry brings in ready cash every

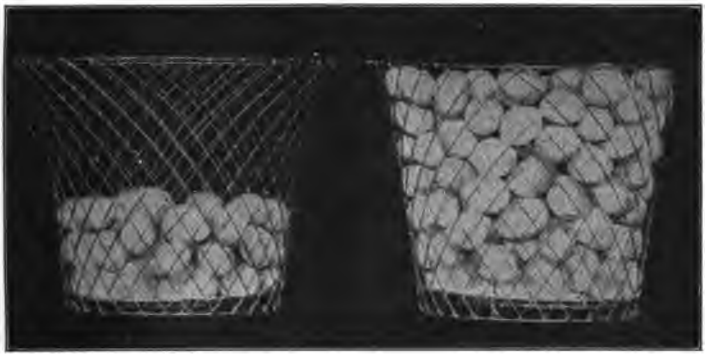

Fig. 230. On the left is the annual product from the average hen, 75 eggs. On the right is the product of one of the good hens at the experiment station, 220 eggs. Why waste food and labor on poor stock?
Courtesy of the University of Minnesota, Department of Extension.

month in the year is a great convenience. In addition, poultry serves a valuable purpose in destroying thousands of injurious insects and in providing the farm home all through the year with fresh, delicious, wholesome human food in convenient quantities. With a reasonable supply of eggs and poultry, a few sheep and dairy cows, an orchard and a garden, the farmer is independent of the city market.

305. **How to Start and How to Improve the Flock.**—One may start a paying flock of poultry either by purchasing from a reliable dealer or a neighbor hatching eggs, day-old

chicks, or a trio of adults. No one breed can be said to be better than all others under all circumstances. Usually it is best to select a breed that has proved itself well adapted to your locality. Get your stock from a flock that is itself strong, active, and healthy. Unless one starts with good stock, failure is certain no matter how much care is given to

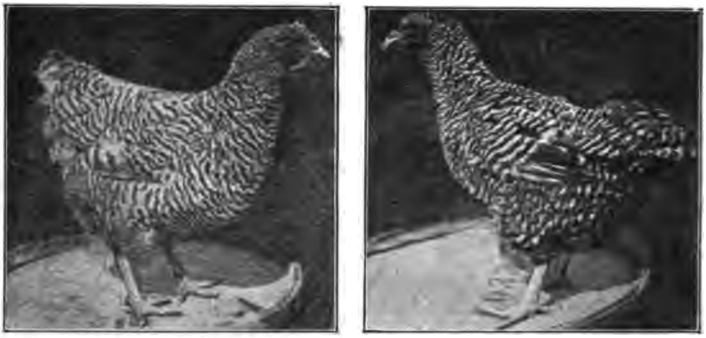

Fig. 231. On the left is a hen with strong constitution; on the right one with weak constitution.

A bird having a strong constitution "should be active and show strong character; its comb should be red; beak short, stout, and well curved; eye bright and clear; face rather short; head moderately broad; neck short and stout; back broad, with width well carried back; breast round and full; body rather long, deep, and broad; tail erect; legs moderately short, straight, and wide apart; bones in legs flat; plumage abundant and very glossy."

Courtesy of the University of Minnesota, Department of Extension.

the flock. Under ordinary conditions a hen that produces less than sixty eggs per year is not profitable. It is a waste to keep such stock when the flock, by intelligent selection and care, may be brought to produce eighty or a hundred or more eggs per year per hen. Even when one starts with good stock, some of the offspring will be poor, hence constant watch should be kept and all hens culled out that from

their size, shape, activity, and general appearance are found to be poor layers. In selecting the breeding stock, choose both males and females of good size, with deep, broad bodies, clear, sharp eyes, stocky, well-developed legs and feet, broad and well-proportioned heads. Select those that have good appetite and are alert and active, and that lay large eggs.

Fig. 232. On the left, a convenient out-door feed-hopper; in centre and on right, convenient and safe feeding and watering devices.

Courtesy of the U. S. Department of Agriculture and the University of Minnesota.

Cull out excitable, flighty birds, and those that lay small or poorly shaped eggs. As the rooster is a powerful factor in transmitting egg-laying qualities, it is very necessary to keep only roosters that are the offspring of the best-laying hens. Roosters therefore must not be selected merely by their appearance. They should have good individual form, but must also have good hereditary qualities.

306. **Feeding and Care of the Flock.**—No matter how good the stock may be, there will be few eggs and poor chicks if the flock is not given proper food and care. First of all an egg is 55 per cent water, hence poultry must have a plen-

tiful supply of clean, fresh water so placed that they can not easily pollute it by getting their feet into it. Some desirable types of homemade feeding-racks are shown in Figure 232. The fountain type of water supply is usually very satisfactory. An inexpensive one can be made by driving a nail-hole on the side and one inch from the top of an empty can. When this is filled with water and inverted in a pan somewhat larger around than the can and two inches deep, one has a satisfactory fountain. The water will flow out till the hole is covered, when it will stop until the water falls below the level of the hole again.

Chickens and all other animals, like plants, must have protein, carbohydrate, and mineral foods in order to thrive, hence the flock should have a mixed diet. When poultry can find plenty of bugs and worms, these supply the needed protein, but when enough protein is not supplied in this way then it must be provided in some other form, such as skimmed milk, cotton-seed meal, meat scrap, beans, peas, clover, or alfalfa. If hens are fed corn and milo alone, they get too much carbohydrate and not enough protein, and hence become too fat and lay few eggs. Hens must have protein in order to lay eggs, but too much protein causes indigestion. The ration must be properly balanced to keep up the energy and animal heat of the hen and at the same time produce eggs. Poultry must also have green food in order to promote health and appetite. If this is not supplied plentifully by the natural range, then green food must be produced and fed to them. Good range for poultry can be provided in winter and early spring by growing oats, barley, wheat, clover, or alfalfa; in late spring and summer by clovers, peas, millet, and sudan.

Ration for Egg Production. The Agricultural and Mechanical College of Texas recommends the following ration for laying hens:

GRAIN

Whole Corn	40 lbs.
Whole Milo	30 lbs.
Barley	30 lbs.

MASH

Wheat Bran	10 lbs.
Wheat Shorts	20 lbs.
Corn Meal	25 lbs.
Ground Milo	25 lbs.
Meat Scraps	20 lbs.

The grain should be fed in a deep litter, giving a light meal in the morning to sharpen their appetites and start them to work, and allowing them all they will eat late in the day in order to send them to roost with a full crop. The dry mash should be kept in hoppers or protected pans all day long and the chickens encouraged to eat all that they will, as this is the part of the ration most important in producing eggs. In addition to the food ration, poultry should be supplied with slaked lime or oyster-shell in order to produce good shells for their eggs. They must also have access to grit. The chicken has no teeth. Swallowing its food whole, it must therefore crush it by rolling it around in its gizzard and grinding it with the gravel kept there for that purpose. If sharp grit is not supplied, the flock will surely suffer from indigestion.

Food Needed per Hen per Year. In the Texas National Egg Laying Contest held at the Agricultural and Mechanical College in 1920–21 it was shown that a good Leghorn

hen will consume 32 pounds of grain and 34 pounds of mash in producing 138 eggs per year. Barred Plymouth Rocks ate on the average 39 pounds of grain and 42 pounds of mash in producing 145 eggs per year. The 532 hens in the contest ate on the average 6.96 pounds of feed for each dozen eggs consumed. The amount of grain and mash consumed by a flock would, of course, vary with the amount and quality of range provided.

307. **Setting a Hen and Handling Little Chicks.**—Always choose for setting a quiet, motherly hen, not heavily feathered. Make sure that she is free of lice and all vermin. Watch the hen, and if vermin appear, dust her thoroughly with a good lice powder, repeat in six days and again about three days before the eggs are due to hatch. Place the nest on the ground in a well-drained and protected place if practicable. Never set a hen in an exposed box on the side of a wall, as the evaporation is so rapid that many dead chicks will result. If the nest must be in a box, then place fresh sod in the bottom and lay the nesting material on top of that.

Chicks are hatched with enough egg yolk in them to provide all the food they need for two or three days. It is therefore best to let the chick rest and sleep at first and to feed it very little for the first three days. Sour milk is the best first food. When the chicks are three days old and are active and hungry, feed them more, giving either common corn bread thoroughly baked, dry, and ground fine or equal parts of dried bread crumbs and rolled oats mixed with 10 per cent of hard boiled eggs. Feed five times a day for five days and give at each time only what the chicks will clean

up quickly. Feed only perfectly fresh, sound food and allow none to lie around the chicks and mould. If mouldy food is eaten it will quickly kill the brood. Grit, shell, and charcoal should be kept where the chicks can get them whenever they want them. Green food must also be provided if it is not supplied by the range.

Where very large numbers of hens are kept, it is economical to use incubators and mechanical brooders in hatching the eggs and caring for the chicks. Those who wish to learn about this can do so from the bulletins to which you are referred.

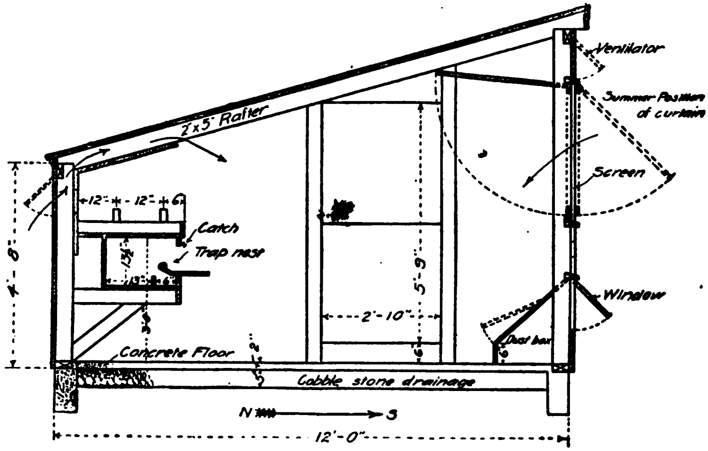

Fig. 233. A model chicken-house.
Courtesy of the U. S. Department of Agriculture.

308. **The Chicken-House.**—The chicken-house should be located on a slightly rolling place, well drained. A sandy loam soil is the best. While expensive poultry-houses are

not necessary, there is real need for a house to protect chickens from sudden and often severe changes in temperature and weather. Allow at least three square feet of floor space per bird. The house needs especially good ventilation, yet the birds must not be exposed to drafts. The north and west sides should be completely closed, but there should be much open space on the east and south walls. These spaces should be covered with netting tight enough to keep out birds and varmints, and should be provided with means of covering them temporarily during extremely bad weather. Arrange to have as much light and sunshine in the house as possible. Attach nests and feed-hoppers to the walls where they can be easily reached, leaving the floor free. The floor should be of cement or sand, raised above the level of the surrounding earth. Roosts should be smooth and movable, with planks to catch droppings placed about ten inches below them. Figure 233 shows a standard plan for a chicken-house. The house must be kept clean and dry and free of vermin if the chickens are to thrive.

309. **Protect Poultry from Insects.**—Fowls must be protected from insect pests. A plentiful supply of dry road dust or coal ashes kept in a box in the corner of the fowl-house will help the fowls in their natural method of suffocating insects. This, however, is not always sufficient. The house, roosts, and everything in it should be, as often as necessary, whitewashed or sprayed with kerosene, kerosene emulsion, or other good spray in order to kill off mites, lice, and other pests. Nests should be cleaned out, straw burned, and the whole nest sprayed. Whenever necessary the fowls should be dusted with insect powder. Commercial sodium

fluorid is an excellent dusting material. Another good, inexpensive insect powder is made by moistening plaster of paris with a mixture of three parts of gasoline to one part of crude carbolic acid. The resulting brown powder should be dusted into the feathers thoroughly. By the use of these and other means that can be found in the bulletins referred to the returns from poultry can be made much greater and more certain. Poultry cannot thrive if infested with vermin.

310. **Breeds of Chickens.**—The American Standard of Perfection, the accepted authority on chickens, recognizes now forty-five standard breeds of chickens. Hundreds of others exist but are not yet recognized as standard. Only a few of the most important breeds can be mentioned here. There are four general types of chickens: the egg type, the meat type, the general purpose type, and the ornamental type.

The Egg Type. The Leghorns and Minorcas from the Mediterranean district are the best-known egg-laying breeds. They are too small and thin to be profitable to raise for meat. These all have smooth shanks, bright eyes, red combs, medium long bodies, and are very active and nervous.

The Meat Type. The Asiatic breeds, the Brama, Cochin, and Langshan, are the leaders of the meat type. They are poor layers, but make large, tender, plump, rapid-growing market fowls. They are large and sluggish, with feathers on their shanks.

The General-Purpose Type. The American Plymouth Rock, Wyandotte, and Rhode Island Red, and the Oppington are the best representatives of this class. They are excellent layers and are also large and early maturing enough

to produce economically the highest quality of market fowl.

The Ornamental Type includes such breeds as the bantams and games.

All these breeds are raised in this section, but the egg type and general-purpose type are justly the favorites. The heavy, sluggish meat breeds, with feathers on their shanks, are not well suited to southern conditions and climate.

311. **Turkeys, Ducks, Guineas, and Geese.**—These fowls should receive much greater attention on the farm than they do. The turkey and guinea are especially valuable insect destroyers and the duck and goose are grass-eating fowls. You can learn about these in the study of your references.

312. **How to Market Eggs and Poultry, and How to Keep Eggs Fresh.**—Eggs evaporate after being laid, are quickly affected by odors, and in all cases deteriorate with age. In warm weather the deterioration is very rapid. They should be gathered as soon as possible after being laid, and put in a cool place. If soiled, they should be wiped off at once with a wet cloth. Grade the eggs according to size and color and market them as soon as practicable. People pay more for fresh, uniformly graded, and clean eggs, especially if they are packed in neat egg cartons.

Preserving Eggs. The best method of preserving eggs during the period of flush production for use later is to mix one part of water glass, which is not expensive and may be bought at any good drug-store, with ten parts of boiled rain water that has been cooled. Place this mixture in a glass or glazed earthenware jar, set the jar in a cool place, and each day place in it, small ends down, perfectly fresh, clean eggs. It is better if the eggs have been made infertile, by having

all roosters removed from the flock during the time in which eggs are being preserved and for two weeks before.

REFERENCES FOR FURTHER READING

"Poultry Keeping," Harry R. Lewis.
"American Standard of Perfection," by American Poultry Association.

Farmers' Bulletins:
Nos. 806, 898, 1052, 1251. On standard varieties of chickens.
No. 236. "Incubation and Incubators."
No. 624. "Natural and Artificial Brooding of Chickens."
No. 64. "Ducks and Geese."
No. 234. "The Guinea Fowl."
No. 791. "Turkey Raising."
No. 1067. "Feeding for Egg Production."
No. 1105. "Care of Mature Fowls."
No. 1110. "Lice, Mites, and Cleanliness."
No. 1113. "Poultry Houses."
No. 1115. "Selection and Preparation for Exhibitions."

Texas Agricultural Experiment Station Bulletins:
No. 206. "Poultry Feed and Feeding Results."
No. 207. "Poultry Houses and Equipment."
No. 220. "Egg Producing Value of Texas Feeding Stuffs."
No. 246. "Report of First Texas National Egg Laying Contest."

The Agricultural and Mechanical College of Texas Extension Service Bulletin:
No. B-10. "Poultry in Texas."
The University of Texas Extension Bulletin:
No. 66. "Poultry on the Farm."

CHAPTER XVIII

THE CARE AND FEEDING OF ANIMALS

313. **How Animals Use Food.**—The animal uses food in two general ways: first, to build up the body and repair used-up tissue; second, to furnish energy for the production of heat and motion. In the first, the animal acts very similarly to a plant, only instead of taking in crude food-material from the soil and air, and first manufacturing foods and then making tissue from these, the animal takes in the ready-made foods provided by the plants and turns these into flesh, bone, milk, wool, or other products. In the production of energy the animal acts similarly to an engine, only instead of burning crude coal in a fire-box by admitting the oxygen of the air, the animal burns the foods and its own tissue by means of the oxygen admitted to the body through the lungs. Just as the growth of the plant is dependent upon the amount and kinds of food materials supplied, and the energy of the engine is limited to the fuel and oxygen used in the fire-box, so the growth and working capacity of the animal are fixed by the amount and kinds of food and air supplied. We can see then that in addition to securing stock of good blood it is necessary to feed and care for them intelligently if the highest returns are to be obtained. Let us then see of what the animal body is composed, how its energy is produced, and how the necessary materials may be most economically supplied.

314. **Composition of Animal Bodies.**—You will recall that plants are composed mainly of water, proteins, fats, and

carbohydrates, together with a little mineral matter. The bodies of animals contain these same substances, which the animals secure by eating and digesting plants or the tissues of other animals that have lived on plants. It is true that the carbohydrates are not found in the animals' tissues, nor are the other compounds there in the exact form that they are in plants. But the carbohydrates are used in the body either in making fats or in supplying energy.

315. **Water in the Animal Body.**—The ordinary animal body is from forty-three to sixty-seven per cent water, which is in the blood, other fluids, and all tissues, even the bones. Water cannot be combined with carbon dioxide in the animal body to form carbohydrates as it can in plants, but it is very important in many ways, helping to dissolve and carry around the foods and to carry out the waste materials. A plentiful supply of clean, palatable water is therefore the first essential of good feeding. A considerable part of this water is supplied in the green foods eaten. Green foods not only supply water, but also increase the digestibility of other foods with which they are eaten, because of being "appetizing."

316. **Protein in the Animal Body.**—Protein is used by the animal chiefly in making lean meat, blood, tendons, skin, hair, hoofs, feathers, eggs, and milk curds. Nothing else can take the place of protein for these purposes. It may also be used to some extent to supply energy and heat, which are, however, mainly and more economically supplied by the fats and carbohydrates. From this it is plain that all growing animals, working animals, milk cows, laying hens, geese that are growing feathers, sheep or goats growing wool must have a plentiful supply of protein in their food, whereas resting adult animals or fattening animals do not need so much

protein or *nitrogenous* (nī trŏj'ē nŭs) food. This protein is found to some extent in practically all parts of all plants fed to stock, but in some, such as corn, Kafir corn, sorghum, and prairie hay, the proportion of protein is so small that these should be supplemented by some other food containing a higher per cent of protein. Wheat, bran, and shorts, cotton-seed meal, beans, peas, and other legumes and alfalfa leaves are rich in protein and make good nitrogenous material to mix with the *carbonaceous* (kär bō nā'shŭs) foods, or those containing mainly carbohydrates and fats.

317. **The Use of Carbohydrates and Fat by Animals.**—Animals neither manufacture carbohydrates in the body nor store them as do plants, nor is the fat which is stored by the animal exactly the same as that in the plant. The animal, however, uses the plant fats and carbohydrates in the production both of animal fat and of heat and energy. The carbohydrates, being rich in carbon, furnish a much more economical material than protein for producing heat and energy by being burned in the body. The fats are even greater energy producers, one pound of fat being equal to two and one-fourth pounds of carbohydrates. The animal fat may accumulate in the body far beyond the present needs and be stored for future use. The amount of fat stored within the body depends upon the animal, the age, the work being done, and the food supplied. Animals hard at work or exposed to excessive cold have to use up the fat to supply energy and heat. The amount of fat in the body varies from five per cent to thirty per cent of the body weight.

Carbohydrates are present in all plants in the form of starch and sugar and of crude fibre. Sugar and starch are

easy to digest and high in nutritive value; the fibre is hard to digest and low in nutritive value. Corn, Kafir corn, milo, rice polish, and molasses are especially rich in digestible carbohydrates. Fat is not so widely and plentifully dis-

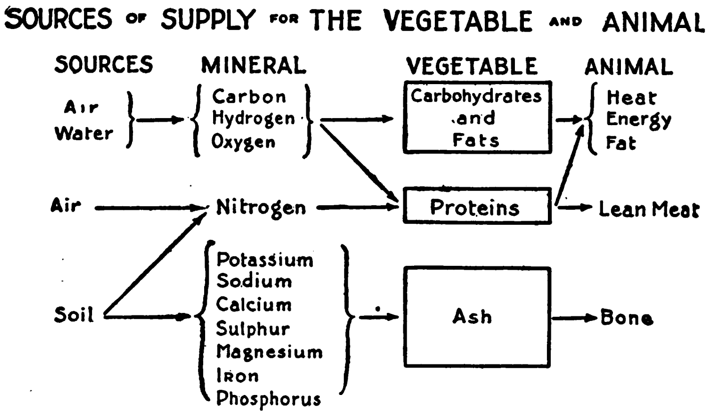

FIG. 234. For the sake of clearness certain details are omitted in the above diagram. For example, bone has some other matter in it besides ash, and protein has in it some of the elements in the lower group of minerals. The diagram is in general correct and affords a good summary to keep in mind.

tributed as the carbohydrates, though all plants contain a little. Pea-nuts, cotton-seed, and soy-beans are especially rich in fat.

318. **Mineral Matter in Animals.**—Mineral matter is found in all parts of the animal—in the blood, digestive fluids, and protoplasm, as well as in the bones. From two to five per cent of the animal body is mineral. These minerals are also in all plants, and are usually obtained by animals in sufficient quantities from any ordinary food. On a highly concentrated ration given to penned pigs or chickens there may be a deficiency of mineral matter, which is usually supplied

to the pig in the form of ashes, and to the chicken in the form of shell or cut bone.

319. **Air, Shelter, Exercise, Rest, and Kind Treatment.**—We have seen that all energy, even that by which the heart beats, the lungs expand and contract, the digestive system works, and other internal bodily activities are carried on, comes from the combination of oxygen with the compounds in the body. For this and other reasons a plentiful supply of fresh air through well-ventilated stables is essential to the highest success in stock-raising. On the other hand, cold draughts are dangerous, while standing out in the open through cold and stormy weather is injurious and uses up food for heat that should go toward flesh and energy production. Properly constructed stables and sheds, therefore, should be provided, having clean, dry beds so that animals may lie down and rest in comfort. It has been proved that a steer gives off from thirty to fifty per cent more heat when standing than when lying down, showing the increased amount of energy consumed in maintaining a standing position. A well-ventilated, comfortable shelter for stock, therefore, quickly pays for itself.

Animals differ from the engine in having a digestive system and assimilating powers by means of which they are able to repair the wear and tear of their own parts. They differ also in having minds that influence the activity of their digestive systems. Therefore all animals must be given exercise to improve appetite and digestion and to stir up the circulation of the blood, which helps to build new tissue and to carry off waste material from the body. They must likewise be given rest always before wear of the tissues is too great to be easily replaced. They must have kind treat-

ment, as the digestive system and other bodily organs do not work so well when animals are irritated and abused.

320. Proportion of Concentrates to Roughage in Rations. —A food, such as wheat or corn or cotton-seed meal, that contains a large per cent of nutriment is spoken of as a *concentrate*, whereas a coarse, rough food, such as hay or sorghum or fodder, that contains a comparatively small per cent of nutriment is called a *roughage*. The proportion of concentrates to roughage in the rations of animals varies greatly, and depends upon the class of animals fed, the purpose in view, and the character of the feed. Roughage, being generally cheaper than concentrates, should be utilized as much as the demands of the particular animal will allow. Generally speaking, growing stock, stock kept for breeding purposes, and idle horses may be given much the greater portion of their food in roughage. Fattening cattle usually give the best returns when the amount of concentrates in the ration is almost double the amount of roughage. On the other hand, dairy cattle generally produce milk most economically when the amount of roughage is about twice the amount of concentrates. Fattening sheep do best usually when roughage constitutes a little less than half of the ration and concentrates the remaining portion. Horses doing hard work require a ration of more than half concentrates, whereas horses doing light work may get along well on a ration made up chiefly of roughage of good quality. Many people allow horses all the roughage they will eat. This is not wise, as animals will overeat just as people do. The horse does not have a large stomach, hence feeding over twelve or fifteen pounds of hay to an average horse does harm instead of good. Owing to the nature of the hog's digestive system this animal

cannot utilize much coarse, bulky material, and therefore its ration must be made up practically altogether of concentrates. However, hogs may utilize advantageously tender green forage plants.

321. **Diet Should Be Varied and Mixed.**—It is always best to vary the diet from time to time, and to feed a mixed ration, as experience has shown that good flavor and variety improve the appetite and digestion of stock as well as of man. The daily ration should contain part roughage, part concentrates, and part green succulent food. It is highly desirable that a portion of succulent or juicy food, either grass, fresh green crops, silage, turnips, or other root crops, be used all the time.

322. **The Basis for Calculating Animal Rations.**—By careful chemical analyses it has been found just how much each ordinary foodstuff contains of these veral *nutrients* (nū′trĭ ĕnts), as the proteids, fats, and other materials that give nourishment are called. By repeated experiments it has also been found how much of each of these nutrients animals of different kinds and sizes need per day to supply their wants. The results of these analyses and experiments are given in Tables I and II. From these tables one can calculate for any animal the amount of each kind of foodstuff that should go into its *ration,* as the amount of food given in one day is called. A ration that contains the nutrients in such proportion and amounts as will meet, without excess of any nutrient, the full requirements of the animal is called a *balanced ration.* It is very important that animals be fed a balanced ration. If the ration is not balaneed because of a lack of sufficient quantity of some nutrient, then the animal will be undernourished. It will not grow properly or will

TABLE I.—AMOUNTS OF DRY MATTER AND DIGESTIBLE NUTRIENTS IN COMMON FOODSTUFFS

A modification of a table in Henry's "Feeds and Feedings"

CONCENTRATES	TOTAL DRY MATTER IN 1 LB.	DIGESTIBLE NUTRIENTS IN 1 LB.		
		CRUDE PROTEIN	CARBOHYDRATES	FAT
Dent corn	.894	.078	.668	.043
Corn and cob meal	.849	.044	.600	.029
Kafir corn	.901	.052	.443	.014
Ground Kafir-corn heads	.864	.042	.424	.012
Milo-maize seed	.910	.049	.448	.013
Ground milo-maize heads	.903	.042	.450	.011
Oats	.896	.088	.492	.043
Wheat	.895	.088	.675	.015
Wheat bran	.881	.119	.420	.025
Wheat shorts	.888	.130	.457	.045
Barley	.892	.084	.653	.016
Rice	.876	.064	.792	.004
Rice polish	.892	.079	.586	.053
Rice bran	.903	.076	.388	.073
Cotton-seed	.897	.125	.300	.173
Cotton-seed meal	.930	.376	.214	.096
Dried brewers' grains	.913	.200	.322	.060
Wet brewers' grains	.230	.049	.094	.017
Cow's milk	.128	.034	.048	.037
Skim milk	.094	.029	.053	.003
Cow-pea	.854	.168	.549	.011
Soy-bean	.883	.291	.233	.146
Tankage	.930	.501	......	.116
ROUGHAGES				
Cotton-seed hulls	.889	.003	.332	.017
Corn stover	.595	.014	.312	.007
Bermuda-grass hay	.929	.064	.449	.016
Johnson-grass hay	.898	.029	.456	.008
Oat hay	.860	.047	.367	.017
Prairie-grass hay	.908	.030	.429	.016
Sorghum hay	.914	.039	.441	.022*
Cow-pea hay	.895	.092	.393	.013
Alfalfa hay	.919	.105	.405	.009
Oat straw	.908	.013	.395	.008
Corn silage	.264	.014	.142	.007
Sorghum silage	.239	.001	.135	.002
Sweet potato	.289	.008	.229	.003
Common beet	.115	.012	.079	.001
Mangel	.091	.010	.055	.002
Flat turnip	.099	.009	.064	.001
Rutabaga	.114	.010	.081	.002

* Determined by Texas Experiment Station.

TABLE II.—AMOUNTS OF FOOD REQUIRED PER DAY BY VARIOUS ANIMALS PER 1,000 POUNDS OF LIVE WEIGHT

From Henry's "Feeds and Feeding"

ANIMAL	PER DAY PER 1,000 LBS. LIVE WEIGHT				
		DIGESTIBLE NUTRIENTS			
	DRY MATTER	CRUDE PROTEIN	CARBOHYDRATES	FAT	NUTRITIVE RATIO 1
1. Oxen	LBS.	LBS.	LBS.	LBS.	
At rest in stall	18	0.7	8.0	0.1	11.8
At light work	22	1.4	10.0	0.3	7.7
At medium work	25	2.0	11.5	0.5	6.5
At heavy work	28	2.8	13.0	0.8	5.3
2. Fattening cattle					
First period	30	2.5	15.0	0.5	6.5
Second period	30	3.0	14.5	0.7	5.4
Third period	26	2.7	15.0	0.7	6.2
3. Milch cows when yielding daily					
11.0 pounds of milk	25	1.6	10.0	0.3	6.7
16.6 pounds of milk	27	2.0	11.0	0.4	6.0
22.0 pounds of milk	29	2.5	13.0	0.5	5.7
27.5 pounds of milk	32	3.3	13.0	0.8	4.5
4. Sheep					
Coarse-wool	20	1.2	10.5	0.2	9.1
Fine-wool	23	1.5	12.0	0.3	8.5
5. Breeding ewes					
With lambs	25	2.9	15.0	0.5	5.6
6. Fattening sheep					
First period	30	3.0	15.0	0.5	5.4
Second period	28	3.5	14.5	0.6	4.5
7. Horses					
Light work	20	1.5	9.5	0.4	7.0
Medium work	24	2.0	11.0	0.6	6.2
Heavy work	26	2.5	13.3	0.8	6.0
8. Brood sows	22	2.5	15.5	0.4	6.6
9. Fattening swine					
First period	36	4.5	25.0	0.7	5.9
Second period	32	4.0	24.0	0.5	6.3
Third period	25	2.7	18.0	0.4	7.0

TABLE II.—AMOUNTS OF FOOD REQUIRED PER DAY BY VARIOUS ANIMALS PER 1,000 POUNDS OF LIVE WEIGHT

(Continued)

ANIMAL		PER DAY PER 1,000 LBS. LIVE WEIGHT				
		DRY MATTER	DIGESTIBLE NUTRIENTS			
			CRUDE PROTEIN	CARBOHYDRATES	FAT	NUTRITIVE RATIO 1
10. Growing cattle, dairy breeds						
AGE IN MONTHS	AV. LIVE WT. PER HEAD, LBS.	LBS.	LBS.	LBS.	LBS.	
2–3	150	23	4.0	13.0	2.0	4.5
3–6	300	24	3.0	12.8	1.0	5.1
6–12	500	27	2.0	12.5	0.5	6.8
12–18	700	26	1.8	12.5	0.4	7.5
18–24	900	26	1.5	12.0	0.3	8.5
11. Growing cattle, beef breeds						
2–3	160	23	4.2	13.0	2.0	4.2
3–6	330	24	3.5	12.8	1.5	4.7
6–12	550	25	2.5	13.2	0.7	6.0
12–18	750	24	2.0	12.5	0.5	6.8
18–24	950	24	1.8	12.0	0.4	7.2
12. Growing sheep, wool breeds						
4–6	60	25	3.4	15.4	0.7	5.0
6–8	75	25	2.8	13.8	0.6	5.4
8–11	80	23	2.1	11.5	0.5	6.0
11–15	90	22	1.8	11.2	0.4	7.0
15–20	100	22	1.5	10.8	0.3	7.7
13. Growing sheep, mutton breeds						
4–6	60	26	4.4	15.5	0.9	4.0
6–8	80	26	3.5	15.0	0.7	4.8
8–11	100	24	3.0	14.3	0.5	5.2
11–15	120	23	2.2	12.6	0.5	6.3
15–20	150	22	2.0	12.0	0.4	6.5
14. Growing swine, breeding stock						
2–3	50	44	7.6	28.0	1.0	4.0
3–5	100	35	4.8	22.5	0.7	5.0
5–6	120	32	3.7	21.3	0.4	6.0
6–8	200	28	2.8	18.7	0.3	7.0
8–12	250	25	2.1	15.3	0.2	7.5
15. Growing fattening swine						
2–3	50	44	7.6	28.0	1.0	4.0
3–5	100	35	5.0	23.1	0.8	5.0
5–6	150	33	4.3	22.3	0.6	5.5
6–8	200	30	3.6	20.5	0.4	6.0
9–12	300	26	3.0	18.3	0.3	6.4

not be able to do as much work as it should. If the ration is not balanced because of an excess of some nutrient, then food is being wasted, and often the animal is injured, as the excess puts a needless strain on the digestive system. The basis, then, of successful and economical stock-feeding lies in using a balanced ration. This ration would naturally differ with different animals and with the same animal under different conditions. Working and growing animals need a larger proportion of proteids, whereas fattening animals need a larger proportion of carbohydrates and fat. Let us now see how to calculate a balanced ration.

323. **How to Calculate a Balanced Ration.**—Suppose that we need a ration for a 900-pound dairy cow giving 22 pounds of milk per day, and the foodstuffs on hand are cotton-seed meal, corn, sorghum hay, and cow-pea hay. By consulting Table II we find that such a cow weighing 1,000 pounds needs 29 pounds of dry matter, 2.5 pounds of digestible protein, 13 pounds of digestible carbohydrates, and .5 pound of fat. A cow weighing 900 pounds will therefore need nine-tenths of this, or: dry matter, 26.1; protein, 2.25; carbohydrates, 11.7; fat, .45. There are several combinations of the materials at hand that would give these amounts of nutrients. The best plan is to take first as a trial ration the amounts that you would judge to be about right; then calculate from the table the amounts of nutrients in that ration and correct deficiencies or excesses of any nutrient by additions or changes until the ration practically agrees with the requirements. As all dried foodstuffs have about ten per cent of water in them we shall need ten per cent more than 26.1 pounds, or 29 pounds, in order to get the 26.1 pounds of dry matter. This 29 pounds should consist of about 9 pounds

of concentrates and 20 pounds of roughage, though these need not be exact, provided the proper amount of each nutrient is present. Let us use for the first trial ration 9 pounds of corn, 10 pounds of sorghum hay, and 10 pounds of cow-pea hay, and see how much of each nutrient that would give. Referring to Table I we find the amounts of nutrients in each of these foods and multiplying the amount in 1 pound by the number of pounds used we get the following:

		PROTEIN	CARBOHYDRATE	FAT
9 lbs. corn=				
9 x .078 lbs. protein	=	.702	....	....
9 x .668 lbs. carbohydrate	=	....	6.012	....
9 x .043 lbs. fat	=	....	....	.387
10 lbs. sorghum hay=				
10 x .039 lbs. protein	=	.390	....	....
10 x .441 lbs. carbohydrate	=	....	4.410	....
10 x .022 lbs. fat	=	....	....	.220
10 lbs. cow-pea hay=				
10 x .092 lbs. protein	=	.920	....	....
10 x .393 lbs. carbohydrate	=	....	3.930	....
10 x .013 lbs. fat	=	....	....	.130
Total nutrients in the ration	=	2.012	14.352	.737
Total demanded by the standard	=	2.25	11.7	.45

Comparing the total nutrients found in the trial ration with the standard ration we find .24 pound less of protein than is required, 2.65 pounds more of carbohydrates and .287 pound more fat than are required. In order to meet the requirements we must either increase the amount of

cow-pea hay to supply more protein and decrease the amount of sorghum hay to decrease the amount of carbohydrates and fat, or we must decrease the amount of corn to reduce the carbohydrates and add some cotton-seed meal to increase the protein. Let us next try this: 6 pounds of corn, 10 pounds of sorghum hay, 10 pounds of cow-pea hay, and 1½ pounds of cotton-seed meal. Referring again to Table I we get the following:

		PROTEIN	CARBO-HYDRATE	FAT
6 lbs. corn =				
6 x .078 lbs. protein	=	.468	....	....
6 x .668 lbs. carbohydrate	=	....	4.008	....
6 x .043 lbs. fat	=	....	....	.258
10 lbs. sorghum hay =				
10 x .039 lbs. protein	=	.390	....	....
10 x .441 lbs. carbohydrate	=	....	4.410	....
10 x .022 lbs. fat	=	....	....	.220
10 lbs. cow-pea hay =				
10 x .092 lbs. protein	=	.920	....	....
10 x .393 lbs. carbohydrate	=	....	3.930	....
10 x .013 lbs. fat	=	....	....	.130
1.5 lbs. cotton-seed meal =				
1.5 x .376 lbs. protein	=	.564	....	....
1.5 x .214 lbs. carbohydrate	=	....	.321	....
1.5 x .096 lbs. fat	=	....	....	.144
Total nutrients in the ration	=	2.342	12.669	.752
Total required by the standard	=	2.25	11.700	.45
Differences	=	.092	.969	.302

This ration still does not meet the exact requirements, but is close enough to it for practical purposes. Of course, the

exact ration could be obtained in a few more trials, but such exactness is not necessary, as the standards are not themselves absolutely exact. There are differences in the digestive powers and demands of animals of the same weight, and there are slight differences in the composition of hays and other foodstuffs when grown under different conditions, so that perfectly exact fitting to the standard is not required. The standards, however, fit the ordinary animal closely enough for practical purposes, and should always be considered in feeding animals. Following the plan shown above you should now calculate rations for several different animals. Rule your note-book and write out everything just as it is done above. This seems quite complicated at first, but after a few examples it becomes easy. At first it is best to make a ration out of only three foodstuffs, as that is simpler.

QUESTIONS, PROBLEMS, AND EXERCISES

198. Draw a plan of the barn lot, barn, and stock shed on your place, give a description of them and tell in what respects they are right and in what wrong.
199. Make a plan for a barn lot, barn, and stock shed for your farm that meets the requirements indicated in this chapter.
200. Weigh the rations given two different kinds of stock on your farm. Calculate the nutrients in these, and if they are not nearly in accord with the standards, prepare rations out of the foodstuffs used that are properly balanced.
201. Try to plan another practical ration for these animals that will accomplish the same result at less expense.

REFERENCES FOR FURTHER READING

"Feeds and Feeding," Henry and Morrison.
"The Feeding of Animals," W. H. Jordan.

Farmers' Bulletins:
- No. 578. "Making and Feeding Silage."
- No. 655. "Cottonseed Meal for Feeding Beef Cattle."
- No. 666. "Colts: Breaking and Training."
- No. 724. "Feeding of Grain Sorghums to Live Stock."
- No. 743. "The Feeding of Dairy Cows."
- No. 777. "Feeding and Management of Dairy Calves and Young Dairy Stock."
- No. 825. "Pit Silos."
- No. 855. "Homemade Silos."
- No. 873. "Utilization of Farm Wastes in Feeding Live Stock."
- No. 874. "Swine Management."
- No. 906. "The Self-Feeder for Hogs."
- No. 909. "Cattle Lice and How to Eradicate Them."
- No. 949. "Dehorning and Castration of Cattle."
- No. 954. "Disinfection of Stables."
- No. 972. "How to Use Sorghum Grain."
- No. 1030. "Feeding Horses."
- No. 1179. "Feeding Cottonseed Products to Live Stock."
- No. 1181. "Raising Sheep on Temporary Pastures."
- No. 1218. "Beef Production in the Corn Belt."
- No. 1229. "The Utilization of Alfalfa."

The A. and M. College of Texas Extension Service Bulletins:
- No. B-39. "The Underground Silo."
- No. B-49. "Silo Construction."

Texas Experiment Station Bulletins:
- No. 203. "The Productive Values of Some Texas Feeding Stuffs."
- No. 242. "Hardening of Pea-nut-Fed Hogs."
- No. 245. "Feeding Values of Certain Feeding Stuffs."
- No. 263. "Rations for Fattening Steers."

CHAPTER XIX

FARM PLANNING AND ACCOUNTING

Planning the Farm

324. **Most Farms Are Without Plan.**—An examination of the farms in any community reveals the fact that but few of them have any well-marked-out plan along which to develop. Fields are irregular in size and shape, often inconveniently arranged and located, necessitating much travel to get to them. Numerous corners in them render the fields difficult to cultivate, and make the full utilization of the land impossible. Irregularity in size of the different fields increases the difficulties encountered in planning satisfactory cropping and rotation systems. Buildings and fences are improperly located, thus interfering with economy in operating the farm. Regard does not seem to have been given to the location of roads, lanes, runs, and pastures for stock. The orchard and the garden seem to have been located by chance, rather than in accord with any well-thought design.

325. **Plan for Economy in Operation.**—Good plans will save time and labor and allow the best and most economical use of equipment and the most complete and profitable utilization of the land. Plan to avoid unnecessary fences and field divisions. The dividing of tillable land into small fields is extravagant of fencing, wasteful of land and of labor and time in cultivating. To fence a square field of two and a half acres requires eighty rods of fencing. Allowing a strip

six feet wide around the field immediately inside the fence for turning uses up seven thousand seven hundred and seventy-six square feet, or seven and fifteen one hundredths

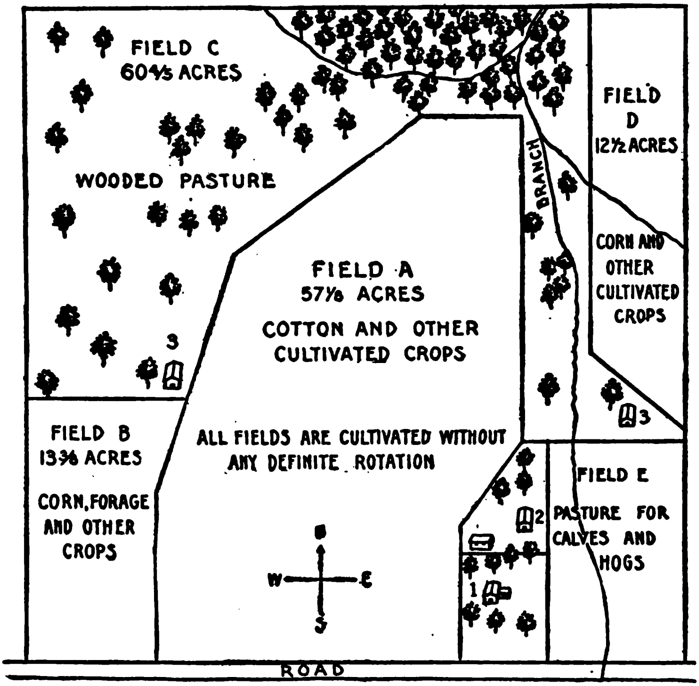

FIG. 235. A 160-acre farm with poor plan of fields and poor cropping system. 1, dwelling; 2, barn; 3, tenant-houses.

per cent of the field. To fence a square field of ten acres calls for only twice the amount of fencing necessary for the two-and-a-half-acre field, while the land necessary for turning is only fifteen thousand nine hundred and ninety-six square feet, or three and sixty-seven one hundredths per cent of

the field. The time consumed in turning in cultivating the two-and-one-half-acre field is twice as great in proportion to the area worked as in the ten-acre field. A forty-acre field

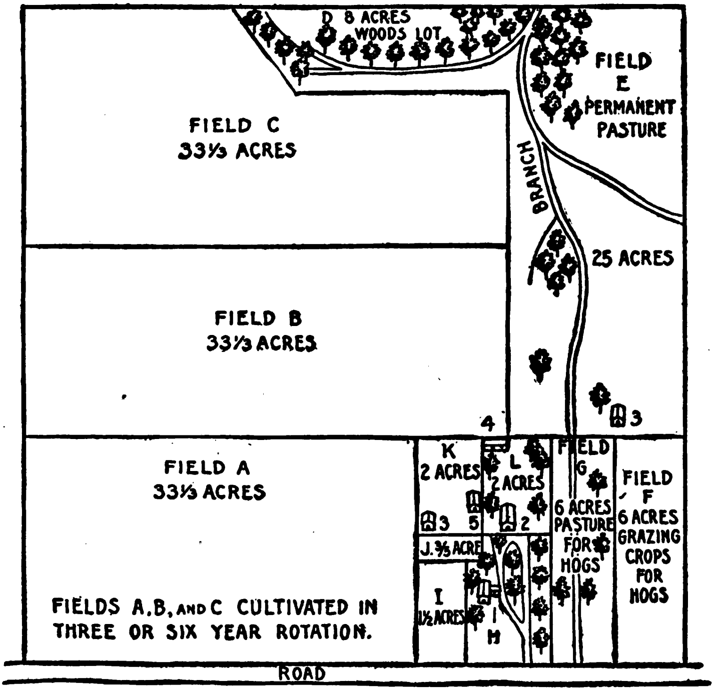

FIG. 236. The same 160-acre farm replanned for systematic management. 1, dwelling; 2, barn; 3, tenant-houses; 4, tool-house; 5, shed for calves and other young stock; *H*, yard and grove about house; *I*, orchard; *J*, garden; *K*, calf pasture; *L*, barn lot.

would have a proportionately greater advantage over the ten-acre field.

Long Fields permit of better use of machinery, teams, and labor in tillage than short ones, especially when rows are run

only one way. In proportion to the area covered, there is just half as much time and land consumed in turning when rows are doubled in length. On a fairly smooth-lying farm when the fields are made rectangular instead of square, each may have an entrance comparatively close to the barn and house, thus rendering them more quickly accessible, saving time and travel in going to and from work.

Uniformity in size of fields is desirable, especially when it is important that the income from crops remain constant from year to year. The planning of cropping systems then becomes simplified, and satisfactory rotations may be more easily carried out. Before deciding upon the number of cultivated fields there shall be on the farm, the rotation or cropping system must be considered. For a three-year rotation three fields are sufficient. For a longer rotation more fields are desirable, or the larger ones may be divided between two or more crops. Each of the cultivated fields should be accessible either through a lane or pasture, so that teams may enter and crops be removed without going over crops growing in the other fields.

326. **The Pasture.**—Work stock render better service and last longer if they have a good pasture in which to graze while not at work. A good pasture affords the very best and cheapest food for live-stock, minimizes the danger from loss of hogs from disease, and reduces the cost of every pound of pork produced. On all general-purpose farms the pasture is an essential to good management. It may perhaps be dispensed with on some of the smaller places where truck and orchard farming are followed exclusively. The pasture should be within easy reach of the farm, should be so arranged that it can be divided into two or more fields to avoid

the necessity of different kinds of stock being together at times when one is liable to interfere with the welfare of the other. Hogs and cows with young calves will often be subjected to much annoyance by mules and by some horses. The pasture does not require frequent cultivation, and may therefore be on land somewhat uneven. It should have shade enough to give stock ample protection from storms and the heat of the sun. Beyond this limit, trees may become a disadvantage. Good, strong fences should surround every permanent pasture. Well-fenced pastures reduce the need of fences around other fields and on other parts of the farm. The pasture should be large enough to accommodate all the stock necessary on the farm. It should be so planted and handled as to furnish grazing during the entire growing period of the year.

327. **The Wood Lot.**—It is well on the general cotton, grain, and live-stock farm to reserve land enough for a wood lot to give the annual fuel supply and from which material, such as posts, usually needed in keeping up the place may be cut. Lands unsuited to cultivation, such as rough areas, fields remote from the centre of the place, or those of doubtful value in producing regular crops, may be devoted to timber-growing. Land set apart for woods should be made to grow trees of value. Others should be worked out. The timber lot should be so managed as to give some harvest each year. It is wise to exclude stock from the lot upon which new trees are being started. The timber lot should not be used as a pasture unless the lot is extensive in area and the number of stock to run in it is very limited.

328. **The Homestead.**—The homestead should be convenient to the main parts of the farm. It should be on a

well-elevated site, convenient to roads and main lines of travel. The dwelling-house should be far enough from the public road for the inmates to escape the dust, annoyance, and noise due to travel, but not so far as to be inconvenient of approach. On a farm of one hundred and sixty acres or more, the house may be located from one hundred to two hundred yards from the road. On a smaller place, and especially with a small house, it may be closer to the road.

The Barn, the building second in importance on the farm, should be at a convenient distance in the rear of the house. There should be a number of trees between the house and the barn, both in order to cut off objectionable views and to serve as a protection of one building from the other in case of fire. The barn should be large enough to house the farm produce and furnish quarters for the stock. It can and should be of artistic design and good, durable construction without being excessively expensive.

There should be a *work-shop* combined with a *tool and implement shed* or house. This building should be placed at a distance of at least one hundred feet from the barn and at a point easily accessible.

Near the run for calves and other young stock there should be located *quarters for young stock*. This building calls for nothing expensive in structure, but should be substantially built.

There should be a few well-planned *poultry-houses*, located at some distance from the barn and tool-house, planned with a view to sanitation. These buildings should be portable and may well be located in the orchard a part of the year.

The *hog-houses* should be portable and located near to or in the hog pasture. At times they may be placed in the

OUTLINE MAP OF FARM

Designate each field by a letter and note acreage and crop hereon

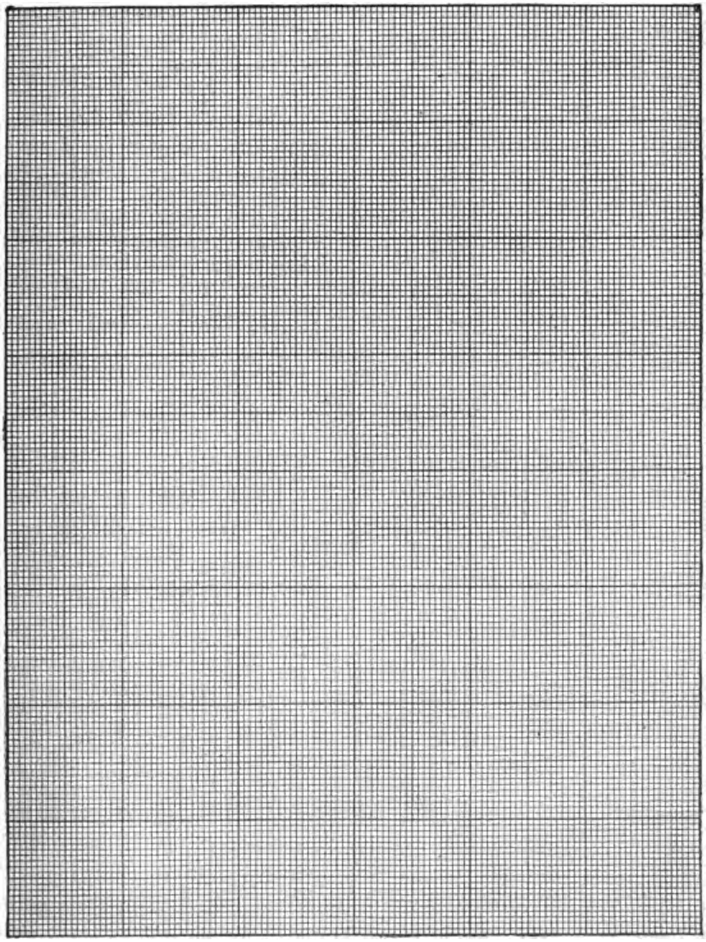

Fig. 237. Fac-simile of page in Farm Diary on which map of farm is drawn.

fields and lots in which some special crops are being grown for the hogs.

329. **Tenant-Houses.**—When the farm is larger than one family can work, provision should be made for tenant-houses. The location of these houses should receive more thought than is usually given such matters. Place them not too close to the barn, nor too far away. Usually they should be placed on the opposite side of the barn and lots from the cultivated fields. Make them comfortable, and give them a good coat of paint occasionally. Have a garden for each one. Attention to such little details makes the places desirable and goes a great way toward solving the labor question.

Farm Accounting

330. **The Simplest System.**—Though it is not possible for us to make a complete study of farm accounting at this time, we will call attention to the simplest method as yet devised, which was prepared by the office of Farm Management, United States Department of Agriculture.

331. **The Farm Diary.**—This is a book seven and three-quarter by nine and one-quarter inches in size, and contains, in addition to a page upon which the farmer draws the plan or outline of his entire farm, a special page for every day in the year. Figure 237 is a fac-simile of the page upon which the plan or outline of the farm is drawn, and Figure 238 is a copy of the page upon which the farmer writes the daily notes upon work performed by men and teams.

332. **Explanation of Daily Notes.**—A "man-hour" is one man's work for one hour, and a "horse-hour" is one horse's work for one hour, so that if a man works from six o'clock

until eleven-thirty in the morning, and from one o'clock until six o'clock in the afternoon, he works ten and one-half "man-hours." If he uses two horses to a cultivator, his team

WEDNESDAY, JUNE 5, 1912

	HOURS	
	MAN	HORSE
6.00 to 11.30 A. M., John plowed field "A"...........	5½	11
6.00 to 11.30 A. M., I repaired fence around field "A"	5½	......
11.30 A. M. to 1.00 P. M., noon.		
1.00 to 6.00 P. M., John plowed field "A"............	5	10
1.00 to 6.00 P. M., I planted cow-peas on oat-stubble in field "C"......................................	5	10
Weather: Cloudy, threatening rain.		
Jim returned from college to-day.		

	RECEIVED	PAID OUT
Coke, Murphy Co., for 1 ton oat hay........	$17.00	....
Smith & Jones, for 10 bu. Irish potatoes, at $1.25	12.50	....
For 4 lbs. butter, at 35c....................	1.40	....
For 5 doz. eggs, at 20c.....................	1.00	....
For 1 grade Jersey heifer, 6 mo. old..........	....	$9.00
For groceries, as per bill of this date..........	....	16.85
	$31.90	$25.85

FIG. 238. Copy of daily page from Farm Diary. The page in the diary is, of course, blank, and such matter as that printed above would be written in from day to day.

has worked twice ten and one-half hours, or twenty-one "horse-hours." In addition to keeping an account of the work performed by men and teams, this page is also used for comments on the weather, the family, social events, etc. It will be observed that on June 5 the weather was cloudy

CORN ACCOUNT

YEAR 19.... ....ACRES

	DR.	CR.
Plowing, at...........per acre...............	....	....
Harrowing, at..........per acre............	....	....
Harrowing, at...........per acre............	....	....
Disking twice, at..........per acre.........	....	....
Planting, at..........per acre..............	....	....
Seed-corn......bushels, at......per bushel...	....	....
First cultivation, at..........per acre.......	....	....
Second cultivation, at..........per acre.....	....	....
Third cultivation, at..........per acre......	....	....
Fourth cultivation, at..........per acre.....	....	....
Hoeing, at..........per acre..............	....	....
Commercial fertilizer, at..........per acre...	....	....
Other fertilizer, at..........per acre.........	....	....
Harvesting, at..........per acre............	....	....
Cost of marketing.........................	....	....
Rent, at..........per acre................	....	....
Or interest on investment in land............	....	....
Interest on investment in equipment (teams, tools, machinery, etc.)..................	....	....
Taxes....................................	....	....
Other items of expense, per acre............	....	....
Other items of expense, per acre............	....	....
Other items of expense, per acre............	....	....
Other items of expense, per acre............	....	....
Other items of expense, per acre............	....	....
Corn sold......bushels, at......per bushel...	....	....
Corn kept for own use.......bushels, value.... per bushel..............................	....	....
Fodder sold...............................	....	....
Fodder kept for own use, value.............	....	....
Silage..........tons at....................	....	....
Totals..............................	....	....
Total profit (or loss), $...............	....	....
Profit (or loss) per acre, $............	....	....

Note to teachers: The teacher should explain the outline of the corn-crop account in detail, having the pupils take assumed cost figures and make estimate upon the cost of an assumed corn crop. It is also advisable to make similar outlines for such crops as wheat, oats, cotton, Kafir, milo, sorghum, cow-peas, and alfalfa.

and threatening rain, and that Jim, a son of the farmer, returned from college. At the bottom of the page is left space for making record of the daily receipts and expenditures, so that the farmer may know from time to time whether or not he is taking in more money than he is paying out.

If a farmer will keep this kind of record from day to day throughout the year, it will be very easy for him to know whether he is paying out more than he is taking in, and to figure out at the end of the season what it cost him to produce each crop and how much he received from it. Similar records should be kept on the cost of producing live-stock.

333. **Crop Accounting.**—In order to determine which of our crops are returning satisfactory profit, it is important that we keep an account of each crop grown on the farm. We must first determine the total cost of production, and after deducting that from the market value of the crop produced, we get the total profit. The outline on page 434, prepared especially for the corn crop, shows how these crop accounts should be kept. With slight modification, it can be rearranged so as to be suitable for keeping record of the cost of any other crop.

QUESTIONS, PROBLEMS, AND EXERCISES

202. With the help of the teacher and your parents fill in the blanks in the corn account and calculate the profit or loss on an assumed crop of corn.
203. Make the changes necessary in the form shown for a corn account and calculate in the same way the profit or loss on a crop of peas and one of cotton.
204. Plant a small crop of your own and keep an actual account, using the diary and crop-account forms.

205. Draw a plan of your father's farm similar to Figure 236, and write a criticism, showing what is good and what not good in the plan, giving reasons in both cases.
206. Make an improved farm plan for your father's farm, and give your reasons for making such changes as you make.

REFERENCES FOR FURTHER READING

"How to Keep Farm Accounts," H. L. Steiner.
"The Farmstead," I. P. Roberts.

Farmers' Bulletins:
No. 511. "Farm Bookkeeping."
No. 572. "System of Farm Cost Accounting."
No. 782. "The Use of a Diary for Farm Accounts."
No. 964. "Farm Household Accounts."
No. 1088. "Selecting a Farm."
No. 1132. "Planning the Farmstead."
No. 1139. "Methods of Analyzing Farm Business."
No. 1182. "Farm Inventories."

Texas Experiment Station Bulletin:
No. 264. "Farm Records and Accounts."

APPENDIX I

ROADS

The Benefits of Good Roads.—It is difficult to make a list of all the benefits of good roads, but the following are among the most important:

1. Good roads decrease the cost of hauling by enabling a team to pull heavier loads and to make a trip more quickly.

2. Good roads make it possible to produce a greater variety of things on the farm. There is not much inducement to raise a certain crop if it is very difficult to get it into town quickly and in good condition. This is especially true of fruit and vegetables, chickens and eggs, and milk and butter. These are among the best money-making products of the farm, but their production is generally limited to farms within a few miles of the towns because of the shameful condition of the country roads.

3. Good roads enable a farmer to sell his products when the market is right, while bad roads may keep him away from market just when prices are best.

4. Good roads are firm and smooth after rains, and therefore allow farmers to do their hauling when the teams are not busy with the ploughs.

5. Good roads give a wider choice of market. If the prices are better in some town a little farther away the farmer can take his products there if the roads are good.

6. Good roads tend to equalize the business on the railroads and in the towns and to keep market prices more stable. This is because the normal amount of business between town and country can go along all the time if the roads are good, whereas, during the time when roads are very bad the entire business of a community is at a standstill.

7. Good roads induce tourists to travel in the country and often control the location of summer homes. Tourist travel is not always appreciated, but it is very valuable to any community both socially and financially.

8. Good roads make possible the rural mail delivery. This is one of the greatest social and educational benefits to any country.

9. Good roads make it possible to build up the country schools by consolidating several small district schools to make a first-class school with higher courses and better equipment. The improvement of our

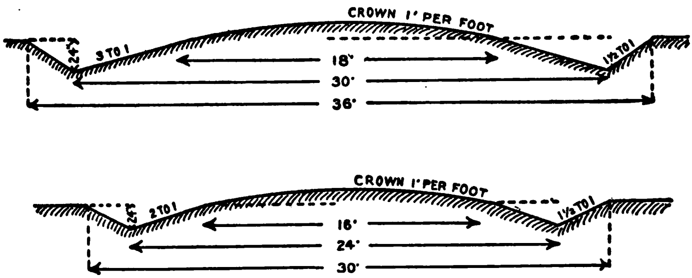

FIG. 239. Standard cross-sections for first and second class earth roads. Iowa Roadway Commission.
From Halligan's "Fundamentals of Agriculture."

country schools is one of the most important public questions. We must have good roads before we can do much with the country high schools.

10. With better facilities for travel and transportation men always adopt more liberal views of life and become better citizens. For instance, in hilly and mountainous countries, travel is always difficult and infrequent. The result is that in such districts, even in the old settled States, we often have the most shocking outbreaks of crime and lawlessness. With good roads through these districts such conditions would gradually pass away.

11. Again, no one wishes to live shut off from friends and neighbors. Building good roads has the same effect as bringing the people closer together because of the greater ease with which they can get from place to place. With good roads all through the country we can get to the neighbors with comfort, can get the doctor quickly when he is needed, can go to social gatherings with pleasure, and can attend church or school with convenience. We can keep better stock, better vehicles,

FIG. 240. A good road in Dallas County, Texas.
Courtesy of "Farm and Ranch."

and better harness, adopt more improved agricultural methods, and raise a greater variety of crops.

Building an Earth Road.—The right of way for a first-class road must never be less than forty feet and would better be fifty or sixty feet. The graded portion of an earth road from ditch to ditch should be at least thirty feet. A greater width will be needed when the ditches must be large and wide. If the road is in a timbered country, the first thing to do is to take out the trees and stumps. If the ground is at all level, the crown can then be built up and the side ditches be cut out with the large four-wheel grader. It usually takes six or eight horses to pull these graders, but they will do the work much more quickly and make a better road at less cost than can be made in any other way. It will usually be necessary to use plow and scrapers at some places.

Drainage.—Drainage is probably the most important thing about any road, especially an earth road. An earth road built of hard earth would be a good road all the time if it were not for the water. The first step in draining a road is to make the water that falls all over the surface of the road to run at once into ditches at the sides. This is done by making the road higher in the middle than at the sides, or making a crown, as this is called. The next step is to make the water flow away from the road along the side ditches until it comes to some creek or other natural outlet. Laying out the side ditches correctly is a very important matter, of which you can learn in the references.

Maintenance: the Road Drag.—Making needed repairs and keeping the road in good condition is called *maintenance*. No road, not even one of gravel or rock, can be made so good that it will last long without being taken care of. With earth roads this consists principally in keeping the ditches clean, repairing culverts, filling washes, and dragging the surface after rains. The most important thing in maintenance of an earth road is the dragging of the surface after every rain. We know that if any travel goes over an earth road just after a rain, while it is still wet, there will be tracks and ruts. If these are allowed to dry and harden it will be weeks and sometimes months before the road becomes smooth. The next rain comes and catches the road with ruts and holes. The water stands in these instead of flowing to the side ditches as it should. This standing water softens the soil at the

Fig. 241. Above, the road after the rain; below, the same road after the use of the split-log drag.

Courtesy of the Agricultural and Mechanical College of Texas.

bottom of the hole so that the first wheel that runs into it goes down. That is how the worst ruts and mud holes are formed. No road, whether of earth, gravel, or rock, can possibly be good long if it has ruts or uneven places on the surface in which water will stand after rains. On a dirt road all this can be prevented by dragging the road just after rains and thus scraping off the ridges and filling up the holes. Various kinds of drags may be used. Some use a piece of railroad rail, some a flat drag made by nailing overlapping timbers together, some a drag made of two halves of a split log or of two timbers two inches by twelve fastened together as shown in Figure 270, some a factory-made metal drag. In pulling any one of these over the road one should allow the end next the ditch to be somewhat ahead of the other end. The drag will then push a little earth toward the centre and thus help preserve the crown of the road. Any of the above types of drag will do the work if used properly and at the right time. The time to use a drag is soon after the rain, while the ground is a little too wet to plow. When thus used, the drag smooths out the rough places and keeps the road ready for travel. It tends to make the surface "cake" and harden and thus soak up less water at the next rain. Most important of all, it preserves the crown of the road and allows all the water to run quickly into the ditches at the next rain.

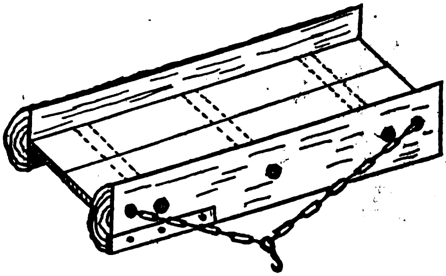

FIG. 242. A good form of split-log drag.

The making and maintenance of sand-clay, gravel, macadam, and other types of roads, as well as the principles of laying out roads, you can learn from the references.

QUESTIONS, PROBLEMS, AND EXERCISES

1. Are roads built and kept in order in your county by bonds and taxation? How are the expenses met?

2. Make a list of the advantages that would come to your community if there were good roads.

3. Why is it right and best to issue bonds and lay out, grade, and surface roads properly rather than continue mending a bad road in a cheap way from year to year?

REFERENCES FOR FURTHER READING

Farmers' Bulletins:
No. 311. "Sand-clay and Burnt-clay Roads."
No. 338. "Macadam Roads."
No. 505. "Benefits of Improved Roads."
No. 597. "Road Drag and How Used."

APPENDIX II

SILOS

Definition.—A silo is an air-tight structure for the preserving of green forage crops such as corn, sorghum, cow-peas, and Kafir corn in their original green state. The material preserved in a silo is called *silage* or *ensilage*. It fills the same place in the diet of live-stock that canned fruits and vegetables do in the diet of people. We are all familiar with the value of green vegetables as a means of keeping the body healthy. Grass is just as necessary to live-stock, but since we cannot always have green grass in the winter-time or during seasons of drought, we build silos to preserve forage crops in their green state. When the silage is placed in the air-tight silo in the green state it ferments, becomes very hot, and causes the formation of carbon dioxide in the silage, which forces out all of the air. This kills the bacteria and keeps the silage in a sweet condition.

Uses of the Silo.—Silos are valuable in several ways. First, they furnish green food for the live-stock all the year round. Second, they preserve the entire stalk in such a form that it can all be eaten by animals, while if it were cured dry the stock would waste a large percentage of it simply because they cannot eat the hard dried stalk. Third, when the season turns out so dry that corn or a similar crop would not produce any grain, it may be harvested while still green and preserved in the silo, whereas if it remained in the field all the fodder would dry up and be destroyed by sun, wind, and rain.

Kinds of Silos.—The first silo was a square pit dug in the ground. This was filled with green fodder and soil was thrown over the top. This silo was inconvenient because it was hard to get the silage out of it. The next kind was the square silo above ground. This kind was discarded on account of its being difficult to exclude the air from the square corners. Wherever air gets in, the silage moulds and spoils. Almost all silos now are built above ground and are built round. They may

be constructed of wooden staves, stone, brick, concrete blocks, reinforced concrete, tile with cement lining, or steel. They must be tall, so that the weight of the silage will be great enough to force out most of the air by packing, and they must be air-tight.

Animals That Eat Silage.—Silage is more important probably for dairy cattle than any other class of live-stock, as it is necessary for them to have green or succulent food to give large amounts of milk. The dairy cow will eat from thirty to seventy-five pounds of silage per day according to her size and capacity. The silo is also very important in the feeding of beef cattle, as it keeps them in good condition and induces them to eat a large amount of foodstuffs that can be raised cheaply. A fine quality of silage is often fed to horses and mules to great advantage. It has too much juice in it to be used advantageously as a food for hard-worked horses or mules. The effect is very much the same as that of fresh grass when fed to such horses or mules. Silage is not a satisfactory food for hogs or poultry. They eat the grain in it, but will not eat anything else except a few of the tenderest blades.

Crops Used for Silage.—The best crops for use as silage are corn, sorghum, Kafir corn, milo-maize, and cow-peas. Sometimes such crops as alfalfa, clover, and Johnson grass are also used. Alfalfa and clover usually contain too much moisture to make a good quality of silage, as the moisture tends to cause the silage to sour.

Time to Harvest Silage Crops.—The crop should be fully mature before it is cut for the silo, as otherwise it will contain too much moisture and will make what is known as sour silage. Corn should be placed in silos just as the ear begins to harden and the kernels begin to dent. Kafir corn, milo-maize, and sorghum should be placed in the silo as soon as the seeds are ripe.

REFERENCES FOR FURTHER READING

Farmers' Bulletins:
No. 878. "Making and Feeding of Silage."
No. 825. "Pit Silos."
No. 855. "Homemade Silos."

APPENDIX III

BOYS' CORN CLUBS AND CORN-JUDGING

How Clubs are Organized.—Under the direction of the teacher a boys' corn club may be formed at any school, but the usual unit of organization is the county. Usually the county superintendent of public instruction issues a call explaining the purpose of the club and in-

FIG. 243. The Smith County, Texas, Boys' Corn-Club exhibit.
Courtesy of "Farm and Ranch."

viting all boys between ten and eighteen years of age who are interested to meet at the county-seat on a certain date. The object of the club is generally explained by both the superintendent and by one of the travelling lecturers of the United States Department of Agriculture. The club is organized and the names of the members are sent to the United States Department of Agriculture, Washington, D. C. Various helpful bulletins and suggestions are then sent by the department to each boy. Usually prizes are offered by local men or business firms

Fig. 244. The Upshur County, Texas, Boys' Corn Club.
Courtesy of "Farm and Ranch."

Fig. 245. The Boys and Girls' Milo Club, Haskell County, Texas.
Courtesy of "Farm and Ranch."

for the best results secured by any boy in the country, and State prizes are offered for the best results in the State. One boy from each State is at times given a trip to Washington as a part of his prize.

Fig. 246. A member of the canning club gathering tomatoes from her garden. *Courtesy of the U. S. Department of Agriculture.*

Basis for Awarding Prizes.—The prizes are awarded on the following basis:

a. Greatest yield per acre	30 per cent
b. Best exhibit of ten ears	20 per cent
c. Best written account showing history of crop	20 per cent
d. Best showing of profit on investment based on commercial price of corn	30 per cent
Total	100 per cent

Fig. 247. An exhibit of the Girls' Canning Club's work.
Courtesy of the U. S. Department of Agriculture.

How to Secure Information.—Full details of the methods of organizing and conducting corn clubs, tomato clubs, and other agricultural and home economics clubs may be secured from the county demonstration agent, the State Agricultural and Mechanical College, or the National Department of Agriculture. These will send helpful bulletins and often give personal assistance in organizing the club.

Corn-Judging.—Corn-judging is a very important part of corn-breeding. There is no absolute standard, as there is more than one type of corn, and a standard for corn grown on one type of soil and under

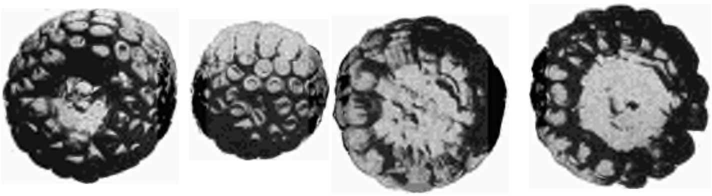

Fig. 248. On the left, a good butt and tip; on the right, two faulty butts.
Courtesy of Professor J. A. Jeffery, of the Michigan Agricultural College.

one set of climatic conditions would be unsuited to corn grown under widely different conditions. There are therefore several methods of scoring corn which differ in some details. The following score-card is one widely used.

CORN SCORE-CARD

1	Trueness to Type or Breed Characteristics	10	
2	Shape of Ear	10	
3	Color: a. Grain	5	
	b. Cob	5	
4	Market Condition	10	
5	Tips	5	
6	Butts	5	
7	Kernels: a. Uniformity of	10	
	b. Shape of	5	
8	Length of Ear	10	
9	Circumference of Ear	5	
10	Space: a. Furrow between rows	5	
	b. Space between kernels at cob	5	
11	Percentage of Corn	10	
	Total	100	

A sample of corn for judging or exhibition consists of ten ears. The several points are judged in the following manner.

Directions for Judging

1. Each ear should have the special characteristics of the type to which it belongs. In scoring cut one-half point for each variation in type of kernel and for each ear that varies from type.

2. The shape should be cylindrical, very slightly tapering, rows should be straight from butt entirely over tip. Cut one-half point for each poorly shaped ear.

3. Both kernels and cob should be free from all evidence of crossing. White corn should have white cob and yellow corn red cob. Cut one-tenth point off for each mixed kernel and ten points off for a cob of wrong color.

Fig. 249. Two excellent ears.
Courtesy of the U. S. Department of Agriculture.

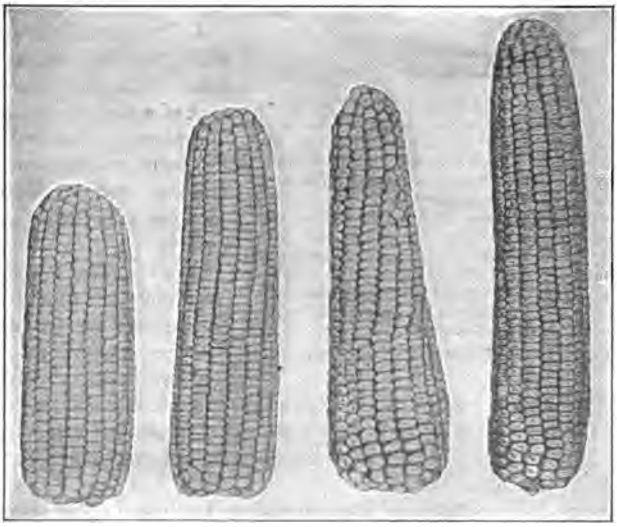

Fig. 250. The ear at the left is too short and thick, though good in other respects; the second is a desirable ear; the third has an enlarged butt and irregular rows; the fourth is too slender.
From the University of Wisconsin Circular of Information No. 8.

4. Corn should be ripe, firm on cob, sound, free from injury or disease, bright in color. Cut one point off for each diseased, injured, immature, or chaffy ear.

5. Kernels should extend over the tip in regular rows and be of uniform size. Cut one-fourth point for badly covered tip, one-half point for every inch of exposed tip, one-eighth point for every eighth inch of exposed tip.

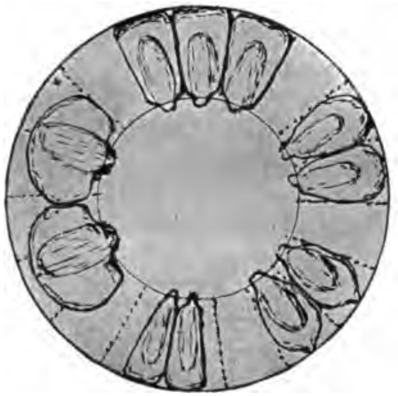

FIG. 251. A study of kernels. The upper three kernels are well proportioned and occupy completely the space between the circumference of the ear and the circumference of the cob. The upper right-hand two kernels are poorly shaped and leave a lot of unoccupied space. The lower right-hand two kernels show how the white rice popcorn kernels occupy the space. The lower two kernels are of the shoe-peg type. The left two kernels show the relative shape and position of flint kernels as compared with the upper three dent kernels.

Courtesy of Professor J. A. Jeffery.

6. Kernels should be well rounded, the shank or ear stalk equal to about one-third of the total diameter of the ear. Cut one-half point for every uncovered butt, three-tenths point for butt covered with flat or small kernels.

7. The kernels should be alike in size, shape, and color. The shape should be that of a wedge, the tip full and plump. Cut one point for each ear with kernels not uniform and one-half for each ear with poorly shaped kernels.

8 and 9. The length and circumference should be up to standard for the variety for the section in which the corn is grown. In general, the circumference should be equal to three-fourths of the length. Take the sum of the excesses and deficiencies in length and cut one point for each inch; do the same for the circumferences and cut one-half point for each inch.

10. The furrows between rows should be small and there should be no space between kernels in the row, nor any noticeable space between the kernels where they join the cob. Cut one-fourth point for furrows one thirty-second to one-sixteenth inch, and one-half point for furrows

one-sixteenth inch or wider. Cut one-fourth to one-half point for each ear that shows noticeable space between kernels at the cob.

11. The per cent of shelled corn should be equal to the standard for the variety. Usually well-matured corn should give eighty-five to eighty-seven per cent grain. Cut one point for each per cent short of standard.

APPENDIX IV

LENGTH OF TIME SEEDS MAINTAIN THEIR VITALITY

	AVERAGE YEARS
Barley	3
Bean	3
Beet	6
Buckwheat	2
Cabbage	5
Carrot	4
Celery	8
Clover	3
Corn	2
Cucumber, common	6
Egg-plant	6
Flax	2
Hop	2
Lettuce, common	5
Millet	2
Muskmelon	5
Mustard	3
Oats	3
Onion	2
Orchard grass	2
Parsnip	2
Pea-nut	1
Peas	3
Pumpkin	5
Radish	5
Rape	5
Rye	2
Salsify	2
Soy-bean	2
Squash	6
Timothy	2
Turnip	5
Watermelon	6
Wheat	2

QUANTITY OF SEED SOWN PER ACRE

Alfalfa (broadcast)	20–30 lbs.
Alfalfa (drilled)	15–20 lbs.
Barley	8–10 pks.
Beans (field)	2– 6 pks.
Blue-grass (sown alone)	25 lbs.
Brome grass (sown alone)	12–20 lbs.
Buckwheat	3– 5 pks.
Cabbage	$\frac{3}{4}$– 1 lb.
Carrot	4– 6 lbs.
Clover (alsike alone)	8–15 lbs.
Clover (red alone)	10–18 lbs.
Corn	6– 8 qts.
Corn (for silage)	9–11 qts.
Cotton	1– 2 bu.
Cow-pea	1–$1\frac{1}{2}$ bu.
Flax	2– 4 pks.
Mangels	5– 8 lbs.
Millet	1– 3 pks.
Oats	2– 3 bu.
Potato	6–20 bu.
Potato (recommended)	15–18 bu.
Pumpkin	4 lbs.
Rape	2– 8 lbs.
Red-top (recleaned)	12–15 lbs.
Rice	1– 3 bu.
Rye	3– 8 pks.
Sugar beets	15–20 lbs.
Sweet potato	$1\frac{1}{2}$– 4 bu.
Timothy	10–20 lbs.
Timothy and clover:	
Timothy	10–15 lbs.
Clover	4–10 lbs.
Turnip (broadcast)	2– 4 lbs.
Vetch (hairy) 1 bu. plus 1 bu. small grain.	
Wheat	6– 9 pks.

WEIGHT AND MEASURE OF FEEDSTUFFS

FEED	ONE QUART WEIGHS	ONE POUND MEASURE
Cotton-seed meal	1.5 lbs.	0.7 qt.
Wheat middlings (flour)	1.2 lbs.	0.8 qt.
Wheat middlings (standard)	0.8 lb.	1.3 qts.
Wheat mixed feed	0.6 lb.	1.7 qts.
Wheat bran	0.5 lb.	2.0 qts.
Whole oats	1.0 lb.	1.0 qt.
Ground oats	0.7 lb.	1.4 qts.
Whole wheat	1.9 lbs.	0.5 qt.
Ground wheat	1.7 lbs.	0.6 qt.
Whole corn	1.7 lbs.	0.6 qt.
Corn meal	1.5 lbs.	0.7 qt.
Corn and cob meal	1.4 lbs.	0.7 qt.
Corn bran	0.5 lb.	2.0 qts.
Hominy meal	1.1 lbs.	0.9 qt.
Corn and oat feed	0.7 lb.	1.4 qts.
Whole barley	1.5 lbs.	0.7 qt.
Barley meal	1.1 lbs.	0.9 qt.
Whole rye	1.7 lbs.	0.6 qt.
Rye meal	1.5 lbs.	0.7 qt.
Rice bran	0.8 lb.	1.3 qts.
Rice polish	1.2 lbs.	0.8 qt.
Cotton-seed hulls	0.26 lb.	3.8 qts.
Alfalfa meal	1.0 lb.	1.0 qt.
Molasses (blackstrap)	3.0 lbs.	0.3 qt.

AVERAGE LEGAL WEIGHTS PER BUSHEL OF SOME FARM PRODUCTS

NAME OF MATERIAL	WEIGHT, IN POUNDS
Apples	48
Apples (dried)	24
Barley	48
Beans	60
Buckwheat	52
Carrots	50
Clover-seed	60
Corn (ear)	70
Corn (shelled)	56
Cotton-seed	32
Flax-seed	56
Kentucky blue-grass (seed)	14
Millet	50
Oats	32
Onions	57
Peas	60
Potatoes (Irish)	60
Potatoes (sweet)	55
Rye	56
Timothy-seed	45
Turnips	55
Wheat	60

GLOSSARY

(The number indicates the paragraph in which the word is defined and the pronunciation given. When the word occurs in the Appendix, the reference gives the number of the Appendix.)

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